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Honorary Editor: A. W. LINEKER, B.Sc.

Assistant Honorary Editors: H. P. ALEXANDER, B.Sc. (Eng.); W. CORMACK, D.Sc.

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Volume 45 — DECEMBER 1954 — Part 111

PROCEEDINGS AT THE FOUR HUNDRED AND FIFTY FIRST GENERAL MEETING

Held at Kelvin House, corner Marshall and Hollard Streets, Johannesburg

Wednesday, 15th December 1954

J. P. ANDERSON (President) was in the Chair and declared the meeting opened at 8.5 p.m.

There were present 75 members and visitors and the Assistant Secretary.

MINUTES

The minutes of the monthly general meeting held on the 25th November 1954, were taken as read, and were confirmed.

MEMBERSHIP

The President announced that in terms of By-Law 5.2.4, the Council had elected the undermentioned candidates to membership of the Institute in the following grades :—

Associate Members : BERNARD HEALD MITCHELL, JAMES HARRISON PICKLES, JOHN LANGTON SALMOND.

Associates : GERT CORNELIUS BEZUIDENHOUT, MICHAEL HENRY GARDE, FRANCIS HENRY FLANTER.

Student : FRIEDEL THEODOR ROHRS.

Transfer from Associate Member to Member : HARRY ROBERT ARTHUR, JOHN DENZIL CARR, WALTER GEORGE THACKWRAY.

Transfer from Graduate to Associate Member : JOHANN DANIEL SAUERMANN.

Transfer from Student to Graduate : HERBERT LUDWIG JUNG, JACOBUS TRIDOUX TRUTER.

Transfer from Student to Associate : MERVYN PETER BOTHA, LOWRENS BOOYSEN, REDVERS QUINTIN WAKFER.

ELECTION OF SCRUTINEERS—ANNUAL BALLOT FOR COUNCIL, 1955

On the proposal of J. T. Allan (Past President), the following were unanimously elected as scrutineers for the annual ballot for Council for 1955 :—

The President, Professor G. R. Bozzoli, J. Stewart-Ross, G. A. Dalton, K. B. Findlay, J. C. Fraser, A. T. Rodwell, Joseph White, H. T. Aspinall and A. W. Lineker.

CONFERENCE OF ENGINEERING INSTITUTIONS OF THE BRITISH COMMONWEALTH

A report of this Conference held in London from the 24th May to 4th June 1954, was presented by Professor G. R. Bozzoli (Vice-President).

The President thanked Professor Bozzoli for his report and said that Professor Bozzoli would be pleased to reply to any questions on the Conference raised by members.

ITEMS OF PRACTICAL INTEREST

An item entitled 'The most economic height of transmission line supports' was presented by F. G. Heymann (Associate Member).

H. P. Alexander (Member) contributed to the discussion on this item.

A further item entitled 'Residual voltages on switching-out of induction motors,' by F. W. Stutterheim (Associate Member), was read by H. P. Alexander (Member).

J. T. Allan (Past President) discussed the item.

CINEMATOGRAPH FILMS

Two cinematograph films entitled 'The Gotland cable' and 'The Amplidyne' were shown and much appreciated by those present.

CHRISTMAS GREETINGS

The President said that as this was the last meeting of the Institute in 1954, he would like to take the opportunity, on behalf of Council and himself, of wishing all members a very merry Christmas and a prosperous New Year.

E. Vivian Perrow (Honorary Member) (Past President), on behalf of those present, reciprocated the President's good wishes and said that members were pleased to see the President's improvement in health and trusted that the year 1955 would see him completely well again.

There were no contributions under the remaining item on the agenda.

The President declared the meeting closed at 9.50 p.m.

Institute Notes

Cape Western Local Centre

Members of the Institute visiting Cape Town are cordially invited to attend general meetings of the Cape Western Local Centre which are held in the Demonstration Theatre, Electricity House, Strand Street, Cape Town, on the second Thursday of each month.

A general meeting of the Cape Western Local Centre was held in the Demonstration Theatre, Electricity House, Strand Street, Cape Town, on Thursday, 19th December, 1954.

Mr C. G. Downie (Chairman of the Centre) was in the Chair and declared the meeting open at 8.15 p.m. Forty-eight members and visitors were present.

The Chairman extended a very cordial welcome to Mr J. Ettershank, President of The South African Institution of Mechanical Engineers.

Mr A. M. Cormack presented a lecture on 'Atomic energy,' which was supported by clearly presented equations and diagrams on the blackboard and a number of illustrations on the screen.

The speaker dealt with his subject in a most able manner, which caused most favourable comment from members; the highly technical aspects of the subjects were treated in a lucid and interesting way.

Professor R. Guelke, Dr W. Schaffer, Messrs J. Reitz, A. N. Richter (Associate Member), J. E. Ettershank, F. D. Opperman (Member), R. R. Gilmour (Associate Member), G. D. G. Davidson (Member), Col. G. H. Webster (Associate Member), and the Chairman contributed to the discussion.

Mr Cormack replied to a number of questions raised by the contributors.

There being no further business, the Chairman declared the meeting closed at 10.35 p.m.

CONFERENCE OF ENGINEERING INSTITUTIONS OF THE BRITISH COMMONWEALTH 1954

Report by Professor G. R. Bozzoli, D.Sc. (Eng.), one of the Institute's Delegates

In 1946 a conference was called in London of the national engineering institutions in the Commonwealth and it was then decided to hold similar conferences every four years, alternately in London and in a commonwealth country. The 1950 conference was held in Johannesburg and this year it fell to me to represent this Institute in London, owing to the most unfortunate illness of our President, Mr Anderson, who would otherwise have gone.

The conference lasted a fortnight and was attended by representatives from the Institution of Engineers, Australia, the Engineering Institute of Canada, the Institution of Engineers, India, the New Zealand Institution of Engineers, the three London Institutions of Civil, Mechanical and Electrical Engineers, and the three South African Institutions of Civil, Mechanical and Electrical Engineers. In addition, an observer was present from the newly formed Rhodesian Institution of Engineers.

Eleven sessions were held, the three London Institutions acting as hosts in daily rotation. Before reporting on the work of the conference, I should mention the lavish hospitality with which the delegates were received and entertained. At the end of the first week all the delegates were taken on a three-day tour of the Cotswolds and no effort was spared to make the trip most enjoyable. A number of visits of great interest were also arranged and all delegates were unanimous in their praise of the excellent organization behind these functions and the extreme cordiality with which they were treated.

The work of the conference is embodied in sixteen Recommendations which have been placed before and approved by the Councils of the participating Institutions, and ten Resolutions which were formulated to guide the further actions of future conferences. These are embodied in a report which will be published in the *Transactions* and my purpose to-night is to summarize this report and comment on certain interesting matters.

The agenda was drafted by the London secretariat in consultation with the various commonwealth Councils and generally agreed upon some months before the conference took place. The most important matters discussed fall under the headings of training and education, the future supply and demand for engineers, the position of the engineering technician, and registration.

i. Training and education

Dealing first with undergraduate teaching, the conference made available to the delegates a publication prepared by E.U.S.E.C. containing details of engineering courses given in seventeen Western European and North American countries. This valuable book was drawn up by representatives from Universities and Technical High Schools in these countries and apart from providing references to engineering qualifications, the drafting of it gave rise to a much closer understanding of each country's methods and problems.

We were then advised of a scheme known as I.A.E.S.T.E.,* originally started by Mr Newby of Imperial College, London University, under which students may spend their long vacation each year in another country. From small beginnings, the number of students to be exchanged this year was 4 200. Twenty-one nations take part, including India and Canada, and the possibility of extending the scheme to South Africa was thoroughly investigated with Mr Newby. Even with the difficulties of time for travel and cost, it was felt that some South African students might be able to join in and an approach to our Universities here has been favourably received. It is likely that the scheme might be working here at the end of 1955. Your Council has

* International Association for Exchange of Students for Technical Experience.

also felt that the bigger organizations in this country might be in a position to offer reciprocal facilities and accept vacation students from abroad during the northern long vacation (July to October).

We next heard of three schemes whereby graduates could be assisted in making their ways to Great Britain for post-graduate experience. The many and generous arrangements offered by large private firms in England are well known, but in addition there is the Athlone Fellowship scheme and the F.B.I. Fellowship scheme. The former operates between Canada and Great Britain, and the latter between Great Britain and any overseas country whose Government is prepared to support it financially.

The Athlone scheme was founded by the Canadian Government, has now been in operation for four years and is most successful. The third scheme is the Colombo Plan, whereby fellowships are offered to graduates from Australia and India to assist them to gain experience in Great Britain. Although the F.B.I. scheme could apply to ourselves, it does not since no financial support for it has been forthcoming.

The nature and extent of post-graduate training was also discussed at some length, and your delegates offered to suggest to their Councils that here also reciprocal facilities might be offered. As a result your Council has set up a Committee to investigate the possibility of offering post-graduate experience to oversea graduates in electrical engineering, particularly as regards mining practice, and it is hoped that something might come of this.

The conference also concerned itself with the educational requirements for those entering the profession. It was held primarily that engineers should have received a liberal education of a character providing a general foundation of culture; in other words, a school curriculum with a cultural bias is preferable to one with a technical bias.

In discussing Institution examinations, it was considered desirable that some uniform standard should be aimed at and the general pattern should be a test of knowledge of:—

i the basic principles of applied science,
ii the application of engineering science to one or other of its main branches,
and *iii* the practice of a particular branch of engineering.

Despite this interest in Institution examinations, the Conference considered that so many suitable courses are available in Universities and Colleges of Technology, that the number of candidates presenting themselves for the examinations is declining, and this fact was welcomed. Institution syllabuses are therefore to be regarded more as a method of setting a standard for recognition of qualifications, than as courses for examination.

ii Professional engineers—future supply and demand

From the discussion on this point the fact emerged that the shortage of engineers is widespread, but that South Africa is the hardest hit of all. Canada found itself short but Australia hardly at all. In fact, the Australian delegates suggested that we might entice young Australian engineers to this country if they were offered sufficient pay.

In Canada, it was interesting to discover that the highest income group, based on income tax returns, was that of the engineers, and the Australian view was that the problem was one of salary. This view was not held by all, it being held that many young men do not enter the profession simply because they are not aware of the profession, it's nature and the rewards apart from financial ones. The three South African Institutions are very much alive to this problem and have set up a joint Committee to tackle the problem. Other bodies in this country are also working on it and joint action between them and the Kelvin House Group is now under way.

This action is in keeping with the spirit of the Conference, which has recommended that the Constituent Institutions should co-operate with approved educational establishments in securing full facilities for an adequate number of engineering students.

iii The position of the engineering technician

Very much bound up with training and shortages is the recent emergence of ideas about the engineering technician. Of particular application to the mechanical and electrical branches, the view is widely held that the shortage lies not in engineers, whose training must be very broad and must therefore take a long time, but in technicians whose training, while rising to equal or greater heights than the engineers, is narrower and therefore takes a shorter time.

For purposes of discussion only, the Conference accepted certain definitions of 'Professional engineer' and 'Engineering technician' which have been adopted internationally. The definitions generally describe the professional engineer as the broadly trained man responsible for planning, managing, designing on a large scale. The technician, following established engineering techniques, undertakes design, development, erection, operation, etc., of plant. The division between the two is vertical, not horizontal; that is to say, the technician is more of a specialist and is more immediately concerned with supervision of the work of skilled craftsmen.

Constituent Institutions are requested to give serious consideration to the question of technicians and their training, and the joint committee referred to earlier has this matter in hand. It is my view that if proper attention is paid to this question, many of our staffing difficulties should fall away.

iv Registration of engineers

An entire session was devoted to this matter. Views were received from countries where registration is in force and from countries where it is not. The former countries were Canada and New Zealand, and the state of Queensland in Australia.

Except for Canada, registration is of a very minor nature. In New Zealand it is intended to operate only to protect the expenditure of public money by local authorities. A recent ballot showed that the vast majority of engineers were opposed to registration and support for such a step has receded even among the younger group.

In Queensland, although legislation exists, registration is virtually dead, and the Australian delegates reported their membership as being very strongly opposed to registration. In India, the possibility exists that registration might be forced upon the profession by the Government, but the delegates were themselves strongly opposed to such a move. The three London Institutions reiterated their view expressed in 1950, that engineers had nothing to gain by registration and a great deal to lose. The Canadian delegates were placed in a difficult position and while they spoke freely in committee, it would not be correct to quote their views. It is nevertheless interesting to see that the conference has recommended that in countries where registration is not in force, the public and the profession are best protected from the practice of unqualified persons by maintaining a high standard of admission to the National Institutions, and not by such registration.

These were the highlights of the discussions. It must be remembered that the Conference is essentially advisory and there is no compulsion on any of the participating institutions to carry out the recommendations. Those of us who were present, however, could not but be impressed by the many experienced views put forward, and our Councils have also realized how much we can learn from the experience of others.

In conclusion, I wish to express my deep appreciation of the action of this Institute in placing their confidence in me as their representative.

REPORT OF THE CONFERENCE OF ENGINEERIMG INSTITUTIONS OF THE BRITISH COMMONWEALTH

London — 24th May — 4th June 1954

In accordance with a decision taken at the previous meeting held in Johannesburg in 1950, the Conference of Engineering Institutions of the British Commonwealth met in London from 24th May to 4th June, The Institution of Civil Engineers, The Institution of Mechanical Engineers and The Institution of Electrical Engineers acting as hosts.

The first meeting of the Commonwealth Conference was held in London in 1946 as a result of an invitation issued by the three London Institutions. Although previously all the Institutions of the Commonwealth had been in correspondence with each other and were generally aware of the various activities in which they were engaged, and of each other's requirements in education and training, discussion round a conference table enabled a much closer and more intimate collaboration to be established, with the fullest understanding of individual conditions.

As a result of these discussions, it was possible to adopt a number of general principles concerning, for example, educational standards, the privileges as visitors that might be accorded to each other's members and the conditions under which papers might be presented before two or more of the Constituent Institutions.

The Conference met again in Johannesburg in 1950, the hosts being The South African Institution of Civil Engineers, The South African Institution of Mechanical Engineers and The South African Institute of Electrical Engineers. On that occasion it was possible to examine the decisions made at the first Conference and to modify them where necessary in the light of experience gained in the intervening four years. It also became evident that the Conference had an important function in making recommendations for the guidance of all the Institutions represented, leading for example to the determination of a common policy in their attitudes towards international organizations, particularly those which might affect professional engineers. There was an implicit recognition that, as each Institution exists to advance the science and practice of engineering in its own territory, any action to this end resulting from a common purpose within all the territories represented would have the added strength which comes from unity.

Of great interest to the Conference and undoubtedly of ultimate benefit to the whole of the profession of engineering, was the establishment of two other Conferences of a similar regional nature. In 1948, the initiative again being taken by the three London Institutions, there was established a Conference of Representatives of the Engineering Societies of Western Europe and the United States of America—which is now briefly referred to as EUSEC—and following this the Pan-American Union of Engineering Societies, briefly known as UPADI, has been inaugurated.

There is a continuing liaison between these three Conferences, representing as they do a very large proportion of the world's professional engineers. With the United Kingdom as a member of the Commonwealth and EUSEC, Canada as a member of the Commonwealth and UPADI, and the U.S.A. as a member of EUSEC and UPADI, this liaison is very real, and the importance of maintaining close contact between the three Conferences has been considered so desirable that a meeting of representatives of all of them was held in Brussels immediately after the Commonwealth Conference.

All who have been associated with the successive meetings of the Commonwealth Conference and the joint meeting in Brussels are convinced that by no means the least important function of such Conferences is the opportunity offered for close personal contacts between office-bearers and officers of the national Engineering Institutions of the countries represented.

It should be remembered that each of the Constituent Institutions of the Commonwealth is autonomous, and in their voluntarily coming together to discuss their common interests the Conference follows in the field of engineering the pattern of the friendly co-operation which exists between the sovereign nations of the British Commonwealth itself.

The Conference was attended by the following delegates :—

AUSTRALIA

The Institution of Engineers, Australia : Mr C. W. Candy, M.I.E.Aust , *President ;* Mr C. H. D. Harper, M.C., M.I.E.Aust., *Secretary.*

CANADA

The Engineering Institute of Canada : Mr D. M. Stephens, B.Sc., M.E.I.C., *President ;* Dr L. Austin Wright, B.A.Sc., M.E.I.C., *Secretary.*

INDIA

The Institution of Engineers, India : Major-General H. Williams, C.B., C.B.E., M.I.C.E., M.I.E.(India), *President ;* Professor M. S. Thacker, B.Sc., M.I.E.E., F.Am.I.E.E., M.I.E. (India), F.A.Sc., F.N.I., *Chairman, Electrical Section.*

NEW ZEALAND

The New Zealand Institution of Engineers : Mr R. S. Maunder, M.I.E.E., M.N.Z.I.E., *President ;* Mr P. R. Angus, I.S.O., A.M.I.Mech.E., M.N.Z.I.E., *Immediate Past President.*

RHODESIA

The Rhodesian Institution of Engineers : *Observer.*—Mr T. W. Longridge, B.Sc., M.I.C.E.

SOUTH AFRICA

The South African Institution of Civil Engineers : Mr C. W. J. A. Sandrock, M.Sc.(Eng.), M.(S.A.) I.C.E., *President ;* Mr A. J. Adams, Hon.M.(S.A.) I.E.E., *Secretary.*

The South African Institution of Mechanical Engineers : Mr L. T. Campbell Pitt, O.B.E., M.I.Mech.E., M.(S.A.)I.Mech.E., *President ;* Mr A. J. Adams, Hon.M.(S.A.)I.E.E., *Secretary.*

The South African Institute of Electrical Engineers : Professor G. R. Bozzoli, D.Sc.(Eng.), A.M.I.E.E., S.M.I.R.E., M.(S.A.)I.E.E., *Senior Vice-President ;* Mr A. J. Adams, Hon.M.(S.A.)I.E.E., *Secretary.*

And by the Presidents and Secretaries of the home Institutions, as delegates, and other senior members, as follows :—

The Institution of Civil Engineers : Mr W. P. Shepherd-Barron, M.C., T.D., M.I.C.E., *President ;* Mr A. S. Quartermaine, C.B.E., M.C., B.Sc., M.I.C.E., *Past President ;* Mr V. A. M. Robertson, C.B.E., M.C., M.I.C.E., *Past President ;* Mr Alexander McDonald, B.Sc., M.I.C.E., *Secretary Designate.*

The Institution of Mechanical Engineers : Dr R. W. Bailey, M.I.Mech.E., F.R.S., *President ;* Mr A. C. Hartley, C.B.E., B.Sc.(Eng.), M.I.C.E., M.I.Mech.E., F.Inst.P., *Past President ;* Mr Brian G. Robbins, M.Sc.(Eng.), M.I.Mech.E., *Secretary.*

The Institution of Electrical Engineers : Mr H. Bishop, C.B.E., B.Sc.(Eng.), M.I.E.E., *President ;* Mr J. Eccles, C.B.E., B.Sc., M.I.E.E., *President Elect ;* Colonel B. H. Leeson, C.B.E., T.D., M.I.E.E., *Past President ;* Mr W. K. Brasher, C.B.E., M.A., M.I.E.E., *Secretary.*

In the course of its ten business sessions the Conference discussed a number of matters of interest to its Constituent Institutions, their members, and the public whom they serve. Much emphasis was placed in the discussions on the fundamental importance of the proper conservation of natural resources, and of ensuring that the attention of all members of the Institutions represented was directed to this matter.

As in previous years the Conference considered a number of detailed questions concerning the education and training of professional engineers and they also studied the criteria which should be applied in assessing the suitability of candidates for membership of the Institutions represented, particularly in respect of their practical training and their responsible experience as engineers.

The question of the desirability from the point of view of the public and of the engineering profession, of the State registration of individual engineers was again reviewed, and the Conference reaffirmed its previously recorded opinion that the public and the profession are best protected from the practice of unqualified persons by maintaining a high standard of admission to the national Institutions, and not by the introduction of such registration where it is not already in force.

For the purposes of its meetings the Conference endorsed the definitions of the terms ‘ professional engineer ’ and ‘ engineering technician ’ already adopted by the EUSEC Conference with a recommendation that where local circumstances permit they should be adopted by the Constituent Institutions for use in their discussions with other bodies and persons.

The Conference reviewed the expected future trend of supply and demand for professional engineers in the territories represented and called attention to the assistance which the engineering profession can give, not only in this important matter but also in ensuring the provision of adequate numbers of fully competent engineering technicians.

Other matters dealt with included measures to secure the most effective interchanges of lectures and speakers on engineering subjects, relations with other international organizations operating in the engineering field, and with non-professional institutions in the territories of the Constituent Institutions.

The work of the Conference is most conveniently summed up in its Resolutions and in the Recommendations which it presented for ratification and endorsement by the Councils of the Institutions represented.

Except in the instances noted under the appropriate headings the findings of the Conference have been ratified by all the Councils concerned.

In addition to the business meetings, the delegates to the Conference also participated in a number of social engagements designed to bring them into contact with representative British engineers, and to let them see examples of British engineering activity in the fields of education, industry and research. These included a reception by Her Majesty's Government, and visits to Hampton Court, Oxford, Cambridge, Stratford-on-Avon and the Cotswolds, in the course of which engineering establishments as well as places of scenic or historic interest were visited. Hospitality of an individual character was also provided by the host Institutions, an example being the holding of an evening Conversazione by The Institution of Mechanical Engineers in their headquarters building.

At a dinner to mark the ending of the Conference the visiting delegates expressed their appreciation of its work and their conviction that the decisions freely arrived at would be of the greatest benefit to the profession of engineering and thus to the public at large.

The next meeting of the Conference will take place in Australia in 1958 at the invitation of The Institution of Engineers, Australia, supported by the New Zealand Institution of Engineers.

RECOMMENDATIONS AND RESOLUTIONS ADOPTED BY THE COMMONWEALTH ENGINEERING CONFERENCE LONDON, 1954

Recommendation 54/1—*Practical Training of Oversea Graduates*

The Conference has received with interest details of existing organized schemes whereby oversea graduates may obtain practical engineering training in the United Kingdom, and recommends to the Councils of the Constituent Institutions that full support should be given thereto. The Conference also recommends to the Councils of the Constitutions that consideration be given to the introduction and extension of such schemes and the provision of facilities for the practical training of young engineers in the territories of the Institutions.

Note.—In approving this Recommendation the Council of The Institution of Engineers, Australia, have made observations on the nature of the training schemes; these observations are under examination by the Executive Committee and will be discussed at the next Conference.

Recommendation 54/2—*Registration of Engineers*

The Conference having again reviewed the present position as to the individual registration of engineers in each of the countries represented, together with the experience of such registration where it has been in force, reaffirms the Recommendation which it addressed in 1950 to the Councils of Constituent Institutions where registration is not in force, that the public and the profession are best protected from the practice of unqualified persons by maintaining a high standard of admission to the national Institutions, and not by such registration.

Note.—The Council of The New Zealand Institution of Engineers have communicated the following comment :—

The New Zealand Institution of Engineers has insufficient knowledge of conditions in countries where registration is not in force to endorse unqualifiedly this recommendation.

It is considered that up to the present time registration has aided in developing the standards of engineering in New Zealand, and in advancing the status of the profession and The Institution.

It is thought that with the present increasing prestige of the New Zealand Institution of Engineers the advantages offered by registration are diminishing.

Recommendation 54/3—*Professional Engineers: Future Supply and Demand*

The Conference recommends to the Councils of the Constituent Institutions that, having regard to the fact that the demand for professionally qualified engineers in the countries concerned seems likely to outrun the supply, they should give close attention to measures to bring about increased recruitment of suitable young entrants to the engineering profession, and suggest as a means to this end the following actions :—

(1) That the professional outlook and high qualifications possessed by their members should be emphasized on all suitable occasions.

(2) That the need for the insistence by employers of professional engineers in private and public industry, and by local and central Government Departments, on proper standards of qualification for the professional engineer should be constantly brought to notice.

(3) That the opportunities for service to the public which the practice of the engineering profession affords, and its consequent rewards, should be brought regularly to the attention of school authorities and parents by the Councils of the Constituent Institutions in order that recruitment to the profession may be stimulated thereby.

(4) That the Constituent Institutions should co-operate with approved educational establishments in securing full facilities for an adequate number of engineering students.

Recommendation 54/4—*Conservation of Natural Resources*

Recognizing that it is essential in the interests of world economy that natural resources be conserved, and also the major responsibility of the engineer in this respect, the Conference recommends :—

(1) That this matter should be constantly stressed to young engineers during their education and training.

(2) That the Constituent Institutions actively encourage the dissemination of information on the subject.

(3) That the Constituent Institutions constantly work to the end that organizations, authorities and industries associated with the conservation and the best and most economic use of natural resources are under the direction of persons with suitable engineering or scientific qualifications and training for this purpose.

Recommendation 54/5—*Public Relations*

The Conference has noted with interest details of the existing measures taken by the Constituent Institutions to establish satisfactory public relations, and recommends that wider attention be given to making known to the public generally the services performed for the community by engineers, by such means as the communication of items of engineering interest to the Press, by the use of broadcasting and by the provision of public lectures, including those to older schoolchildren, demonstrations, films and other suitable means.

Recommendation 54/6—*Reciprocal Facilities for Members of Constituent Institutions*

Measures based on Resolutions and Recommendations adopted at the 1946 and 1950 meetings of the Conference, having worked well, particularly for younger members engaged in post-graduate training schemes, the Conference makes the following Recommendation, superseding Resolution VI of 1946 and Recommendation 2 of 1950 :—

That members of one of the Constituent Institutions visiting the territory of another should receive appropriate facilities from the Institution of the territory visited, for a period of twelve months if desired. Members availing themselves of these facilities should preferably be accredited by a letter of introduction or similar document; early notice of arrival will enable the most effective steps to be taken to help such visitors.

Recommendation 54/7—Educational Requirements

The Conference has received with satisfaction reports of actions taken by the various Constituent Institutions in the implementation of Resolutions IX and X of the 1946 Conference, which stated :—

Resolution IX of the 1946 Conference

That a common standard of general education for those entering the profession should be required by all the Constituent Institutions, ensuring that engineers have received a liberal education of a character providing a general foundation of culture and that for this the Councils of the Constituent Institutions should adopt a standard not less than that of the Common Preliminary Examination adopted by the home Institutions for admission to their Student Membership.

Resolution X of the 1946 Conference

That it being considered desirable to work towards a uniform standard of examination each Constituent Institution be recommended to model any examination it holds, accepts or influences, on the general pattern worked out by the three home Institutions as a test of knowledge of :—

(i) the basic principles of applied science,
(ii) the application of engineering science to one or other of its main branches, and
(iii) the practice of a particular branch of engineering.

Reciprocal recognition must lie always between the Institutions concerned and must depend upon the degree to which a common standard is reached.

The Conference now recognizes and welcomes the fact that greater availability of suitable courses and places in universities and colleges of technology will result in a continued decline in the number of candidates presenting themselves for examination by the Institutions themselves. These developments will progressively remove the necessity of designing syllabuses to suit the older and partly self-educated candidates. In consequence the Conference recommends that when framing syllabuses the aim should be that they should serve as models for college courses in engineering; in this way the Constituent Institutions can most effectively influence the level and pattern of courses of engineering education, a matter of importance equal to, if not greater than, determining the nature of the examination by which a candidate's knowledge can be attested.

The Conference also finds that the word 'reciprocal' which appears at the end of Resolution X of the 1946 Conference has given rise to misunderstanding, and as the Conference lends no support to the principle which this word purports to establish, it has resolved to delete the word.

Note.—This Recommendation has not been accepted by the Council of The Institution of Engineers, Australia; their reasons have been communicated to the other Constituent Institutions and will be brought forward for discussion at the next Conference.

Recommendation 54/8 — EUSEC Conference on Engineering Education

The Conference recommends that the Councils of the Constituent Institutions should support the EUSEC Conference on Engineering Education and should accept invitations to participate in its work. When the attendance of a representative is impracticable they should ask to receive the reports and working papers of the Education Conference.

Recommendation 54/9—Definitions of 'Professional Engineer' and 'Engineering Technician'

(*a*) The Conference has accepted for the purpose of its discussions the definitions of the terms 'professional engineer' and 'engineering technician' already adopted for a similar purpose by EUSEC.

(*b*) The Conference recommends to the Councils of the Constituent Institutions whose local circumstances permit that they should adopt these definitions for use in their discussions with, and representations to, other bodies and persons.

(*c*) These definitions are as follows :—

Professional Engineer

A professional engineer is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering science and knowledge, notably in research, designing, construction, manufacturing, superintending, managing and in the education of the engineer. His work is predominantly intellectual and varied, and not of a routine mental or physical character. It requires the exercise of original thought and judgment and the ability to supervise the technical and administrative work of others.

His education will have been such as to make him capable of closely and continuously following progress in his branch of engineering science by consulting newly published work on a world-wide basis, assimilating such information and applying it independently. He is thus placed in a position to make contributions to the development of engineering science or its applications.

His education and training will have been such that he will have acquired a broad and general appreciation of the engineering sciences as well as a thorough insight into the special features of his own branch. In due time he will be able to give authoritative technical advice, and to assume responsibility for the direction of important tasks in his branch.

Engineering Technician

An engineering technician is one who can apply in a responsible manner proven techniques which are commonly understood by those who are expert in a branch of engineering or those techniques specially prescribed by professional engineers.

Under general professional engineering direction, or following established engineering techniques, he is capable of carrying out duties which may be found among the list of examples set out below.

In carrying out many of these duties, competent supervision of the work of skilled craftsmen will be necessary. The techniques employed demand acquired experience and knowledge of a particular branch of engineering, combined with the ability to work out the details of a task in the light of well-established practice.

An engineering technician requires an education and training sufficient to enable him to understand the reasons for and purposes of the operations for which he is responsible.

The following duties are typical of those carried out by engineering technicians :—

Working on design and development of engineering plant and structures ; erecting and commissioning of engineering equipment and structures ; engineering drawing ; estimating, inspecting and testing engineering construction and equipment ; use of surveying instruments ; operating, maintaining and repairing engineering machinery, plant and engineering services and locating defects therein ; activities connected with research and development, testing of materials and components and sales engineering, servicing equipment and advising consumers.

Note.—This Recommendation has not been accepted by the Council of The Institution of Engineers, Australia ; their reasons have been communicated to the other Constituent Institutions and will be brought forward for discussion at the next Conference.

Recommendation 54/10—*Training of Engineering Technicians*

The Conference calls attention to the importance of the engineering technician and to the reliance which is placed upon him by the professional engineer and to the responsibility which arises in consequence for professional engineers to do all in their power to secure proper and adequate facilities for the education and training of engineering technicians. It accordingly recommends that the Councils should take such steps as are consistent with their constitutions and with the practices of their countries to promote the necessary measures to this end.

Recommendation 54/11—*Extent of Encouragement to be given to Non-Professional Institutions*

The Conference recommends to the Councils of the Constituent Institutions that, in addition to interesting themselves in measures for the education and training of engineering technicians, they should give attention to the need to foster the continued interest of technicians in developments in their own branches of engineering. The Conference suggests that this can be helped by proper measures of assistance by the Constituent Institutions to associations for engineering technicians operating in their territories ; where no such associations exist the possibility of stimulating their foundation might usefully be investigated.

Recommendation 54/12—*Practices of the Constituent Institutions in interpreting the terms 'Practical Training' and 'Responsible Experience'*

The Conference has noted the practices of the Constituent Institutions in interpreting their requirements for 'practical training' and 'responsible experience' and draws the attention of the Councils of the Institutions to the importance of ensuring that their requirements for practical training call for an adequate range of engineering activities under organized supervision; and in assessing responsible experience, of placing suitable emphasis on the need for responsibility as an engineer.

Recommendation 54/13—*Abstracting Services in the Engineering Field*

The Conference has followed with interest the further developments in the study of abstracting services in the engineering field undertaken by the EUSEC Working Party and has addressed a request for the Constituent Institutions to be kept informed. The Conference recommends to the Councils of the Constituent Institutions that so far as is practicable they should support the work and proposals of the EUSEC Abstracting Services Working Party and convey to them details of any known requirements of their members or other observations which they may wish to make.

Recommendation 54/14—*Engineering Codes of Practice*

Recognizing that the preparation of codes of good practice concerning the installation, operation and maintenance of engineering plant and apparatus and the utilization of engineering materials and appliances is the responsibility of professional engineers, the Conference invites the Councils of the Constituent Institutions to note the scheme for the preparation of Codes of Practice operating in the United Kingdom and the advantages which follow from the systematic codification of good practice in various sections of the engineering field.

Note.—This Recommendation has not been accepted by the Council of The Institution of Engineers, Australia; their reasons have been communicated to the other Constituent Institutions and will be brought forward for discussion at the next Conference.

Recommendation 54/15—*Engineering Institutions: Extra-territorial activities*

Having reviewed the extra-territorial activities of the Constituent Institutions as they have been carried on in the light of Resolution VIII of 1946, the Conference recommends that the Councils of the Constituent Institutions should reaffirm the terms of that Resolution, which were as follows :—

> That, having regard to the announced policy of the Home Institutions regarding the formation of Branches oversea, it is undesirable for any of the Constituent Institutions to create Branches in the territory of any of the other Constituent Institutions and that their members in any territory in which another Constituent Institution operates should be encouraged to join with that Institution and to support it. It is recognized that it may be necessary to continue for a time such arrangements as are already in existence.

The Conference has noted with satisfaction the willingness of the Constituent Institutions to help each other by exchanging papers, particularly in specialist engineering fields.

Recommendation 54/16—*Relations with other International Organizations operating in the Engineering Field: FIANI*

The Conference has received a report of the activities of the International Federation of National Engineering Associations (FIANI) and of the actions taken by the EUSEC Conference in its regard. As a result the Conference recommends that the Councils of the Constituent Institutions should endorse the actions taken by EUSEC at its meetings in 1951 and 1953 respectively, which were as follows :—

EUSEC Conference Resolution 51/5—*Fédération Internationale d'Associations Nationales d'Ingenieurs (FIANI)*

The Conference has been informed of the recent establishment of an International Federation of National Association of Engineers (FIANI).

The Conference notes that some of the aims and objects of this new Federation are identical with those already dealt with or envisaged by EUSEC.

It considers that it is imperative that duplication of effort be avoided in the field of international co-operation of engineers.

The Conference having been established with the view to collaboration between national societies dealing with engineering matters of a scientific and technical nature, is of opinion that such matters should not appear among the activities of new international organizations of national engineering societies.

EUSEC Conference Recommendation 53/6—Relationship with FIANI

After having explored the essential differences as the purposes for which each organization is constituted, their structures and their *modus operandi*, the Conference resolves to adhere to the policy decided upon at the 1951 Conference.

It is recommended that the Constituent Institutions should inform the Secretariat of any activities initiated by FIANI in their countries.

RESOLUTIONS OF THE CONFERENCE

Resolution 54/I—*Conference Booklet*

(*a*) That a second edition of the Conference booklet should be prepared, to include additional information received from the Constituent Institutions and a report of the present Conference.

(*b*) That the booklet should be republished every eighth year, following the meetings of the Conference held in London, unless in the view of the Conference Executive Committee, earlier publication is desirable.

Resolution 54/II—*Practical Training of Oversea Graduates*

Recognizing the utility of making available in good time beforehand the fullest possible details of graduates arriving from oversea for practical training, each Constituent Institution undertakes to send these particulars for any graduate leaving its country, to the appropriate professional Institution of the country to be visited.

Resolution 54/III — *EUSEC Conference on Engineering Education*

The Conference has received with interest details of the setting up of the EUSEC Conference on Engineering Education. It welcomes this initiative and asks that the Constituent Institutions be kept informed of the outcome of its discussions.

Resolution 54/IV—*Practices of the Constituent Institutions in interpreting the terms 'Practical Training' and 'Responsible Experience'*

The Conference has received with interest reports from the Constituent Institution on their respective practices in interpreting the terms 'practical training' and 'responsible experience,' and expresses the wish that the Constituent Institutions should keep one another informed of any developments by communicating details to the Secretariat.

Resolution 54/V—*EUSEC Conference in Paris —September* 1953

The Conference has noted with interest the setting up by EUSEC of a Working Party to discuss policies and procedures in respect of lecturers from other countries; and suggests that the Constituent Institutions be kept informed of the progress of the work.

Resolution 54/VI—*Abstracting Services in the Engineering Field*

The Conference has followed with interest the further developments in the study of Abstracting Services in the Engineering Field undertaken by the EUSEC Working Party and requests, as before, that the Constituent Institutions be kept informed.

Resolution 54/VII—*Investigations of Technical Problems covered by Committees of the Constituent Institutions*

In order to facilitate liaison, the Secretariat of each Constituent Institution should send annually to each of the others a list of technical committees with whom they are associated and also, at the time of its commencement, a note of any new work which is to be undertaken.

Resolution 54/VIII — *Relations with other International Organizations operating in the Engineering Field: UATI*

The Conference has noted with interest the setting up by UNESCO in October 1950 of the Union of International Engineering Organizations having as its object the co-ordination of programmes of the international specialist engineering Congresses which constitute its members to avoid clashing of dates, overlapping of subject matter and the like.

Resolution 54/IX—*Election of New Members of the Conference*

Having taken into consideration an application for membership of the Conference received from the Rhodesian Institution of Engineers, the Conference resolves that an invitation be addressed to the Rhodesian Institution to become a member of the Conference and to be represented at the 1958 and subsequent meetings. The Conference has welcomed the participation of an observer from the Rhodesian Institution in its present deliberations.

Resolution 54/X—*Next Meeting of the Conference*

The Conference has accepted with pleasure an invitation conveyed from The Institution of Engineers, Australia, supported by The New Zealand Institution of Engineers, that the 1958 Meeting of the Conference be held in Australia, preferably in the early months of that year.

ITEMS OF PRACTICAL INTEREST

The most economic height of transmission line supports

By F. G. HEYMAN (Associate Member.)

In order to determine the best height for transmission line supports in practice it is necessary to calculate the cost for various heights of support and to select the most economic height.

However, capital cost is not the only consideration but maintenance costs should also be estimated and reliability in service taken into account. Since the insulator string is a weak point from the point of view of flashover, it is desirable to use as long a span as possible in order to reduce the number of supports.

By making some simplifying assumptions it is possible to arrive at a value for optimum height of support and hence optimum span.

Consider a straight length of transmission line over flat country.

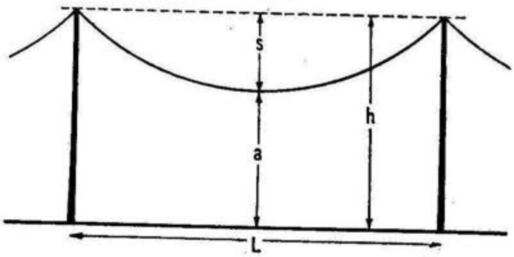

Fig. 1.

Assume that the cost of a support (including erection, insulators, etc.) is a function of the height h. It is simplest to assume that the cost is proportional to h^n.

If the span is L, then the cost of supports per unit length will be proportional to h^n/L.

i.e. Cost per unit length: $C = \dfrac{kh^n}{L}$

The minimum cost is found by differentiation—

$$\frac{dC}{dL} = k\left\{\frac{nLh^{n-1}\cdot\dfrac{dh}{dL} - h^n}{L^2}\right\} = 0$$

$$\therefore \quad nLh^{n-1}\cdot\frac{dh}{dL} = h^n$$

$$nL\frac{dh}{dL} = h \qquad \ldots \ldots \ldots \ldots \quad 1$$

The height is the sum of the sag and the clearance between the lowest point of the conductor and ground. The clearance a is fixed by regulation. Sag is approximately given by the following relation (see *Electrical Power* by A. T. Starr, p. 57).

$$S = \frac{wL^2}{8T} \qquad \ldots \ldots \ldots \ldots \ldots \quad 2$$

where w = effective conductor weight per unit length

T = conductor tension.

Thus $h = a + s = a + \dfrac{wL^2}{8T}$

$$\therefore \quad nL\frac{dh}{dL} = nL\frac{wL}{4T} = 2ns$$

Thus from equation 1, for minimum cost :—

$$h = a + s = 2ns \qquad \ldots \ldots \ldots \ldots \quad 3$$

$$\therefore \quad s = \frac{a}{2n-1} \qquad \ldots \ldots \ldots \ldots \ldots \quad 4$$

and $$h = \frac{2na}{2n-1} \qquad \ldots \ldots \ldots \ldots \ldots \quad 5$$

Thus s and h are expressed in terms of the clearance a. The following table shows how these quantities depend on n :—

n ...	0·75	1·0	1·25	1·5	1·75	2·0
s/a ...	2·0	1·0	0·67	0·5	0·4	0·33
h/a ...	3·0	2·0	1·67	1·5	1·4	1·33

The exponent n probably lies between 1·0 and 1·5, but this would have to be estimated for each individual case.

The following two examples indicate the way of estimating :—

i In the case of a cylindrical pole of constant cross section, the cost of the pole is proportional to its length. Thus $n = 1$ if the factors which do not depend on the height are neglected. This would, however, not be valid and therefore the effective value of n may be expected to be somewhat less than unity.

ii If it is assumed that the bending moment to be resisted at the base of a pole is proportional to the height of the pole, then the pole cross-sectional area should increase with the square root of the height. Thus the cost of the pole will approximately increase as $h^{1\cdot5}$. If the factors which do not depend on h are taken into account the effective value of will be less than 1·5.

It is more difficult to deal with fabricated supports, but it is probable that an extreme value of n may be 2 and that it normally lies between 1·0 and 1·5.

Thus the optimum height probably lies between $3a/2$ and $2a$, but it is usually preferable to employ somewhat higher supports in order to have longer spans for greater reliability as discussed above. The cost does not rise rapidly with increase in height of support and for an increase of 5 per cent in capital cost the height may be increased by 23 per cent (70 per cent increase in sag, 30 per cent increase in span) if $n = 1\cdot5$. For $n = 1$, the height may be increased by 45 per cent, which means 90 per cent increase in sag and 38 per cent increase in span, whilst cost only rises by 5 per cent.

It is also evident that an error in the estimate of n will not be very serious.

When copper conductors are employed, a safety factor of 2 is assumed, and allowing 100 per cent weight increase for wind and ice loading, the relation between sag and span is approximately as follows :—

Sag ...	5	10	15	20	25	30	35 ft
Span ...	370	530	650	750	840	920	990 ft

The minimum allowable clearance to ground at the lowest point of the conductor lies between 18 and 23 feet depending on the voltage.

In the case of a clearance of 20 ft and $n = 1\cdot5$, the optimum sag is 10 ft and for 5 per cent increase in cost the sag is 17 ft giving spans of 530 ft and 690 ft respectively.

When $n = 1$, the optimum sag is 20 ft and for 5 per cent increase in cost the sag is 38 ft giving spans of 750 ft and 1 030 ft respectively.

Steel-cored aluminium conductors are lighter and stronger than the equivalent copper conductors and therefore longer spans may be employed for the same sags.

The foregoing indicates that it is not possible to determine optimum conditions exactly but that it is possible to arrive at a reasonable estimate of span, sag and height of support, using the above approximations.

DISCUSSION

H. P. Alexander (Member) : It has been most interesting to hear Mr Heymann's remarks but, from what he has said, I am inclined to think that he has over-simplified his problem. To say that the cost of a line is a function merely of the height of the pole or structure is, I think, making it too simple.

In a recent journal of The Institution of Electrical Engineers, London, some information was made available by Mr Ryall when he was discussing the economic choice of steel towers, and used an equation in which the cost was a function of the height of the structure multiplied by the square root of the bending moment.

It is most important that the bending moment does come in, and I think also that in the case of pole lines the simple equation that cost is proportional to h^n should be augmented by a constant term which is independent of the height of the pole as well as by some additional term involving h^2 or h^{2n}.

The factors that cause me to make that statement are, firstly, that maintenance, to which Mr Heymann has made mention, is a function of the number of supports in the line, but is independent of their height so that it is an annual cost for each support which can be simply converted to an equivalent increase in the first cost of each support. Secondly, there is a constant term in the cost of a transmission line support represented by the cost of the insulators and hardware on each pole which, in the case of a simple wood-pole line, can often be in excess of the cost of the pole itself.

I think that although Mr Heymann has been inclined to over-simplify the matter, I do agree with him that the values of his parameters are not critical because when a curve is drawn relating the cost per mile of a transmission line with span length there is a very wide range of span length over which the minimum values of cost do not vary much. Thus the most economical span lies over quite a considerable range of span.

In Mr Heymann's item of technical interest he used the equation that the cost per unit length of line was $C = \frac{Kh^n}{L}$ where L was the span length. I think Mr Heymann should have made it quite clear that the constant K itself included a constant which converted the span length L into the length of the line, otherwise it looks as if his cost per unit length is really the cost per span.

Voltage decay in induction motors on being switched out

By F. W. STUTTERHEIM (Associate Member)

In an induction motor connected to a three-phase supply the magnetizing current which flows in the stator winding produces a magnetic flux of constant amplitude which rotates round the air gap at synchronous speed. This flux passes through the rotor and cuts the rotor winding at the slip speed of the machine. What happens when the supply is interrupted is discussed in these notes.

When the supply circuit-breaker to a motor is opened the magnetizing current is interrupted and the flux due to it would tend to collapse. The flux, however, is enclosed by the short-circuited rotor winding and, in accordance with Lenz's Law, any decrease in the flux induces a current in this winding which tends to maintain the flux. The magnetizing current is thus transferred from the stator to the rotor and the flux rotates round the air gap no longer at synchronous speed but at the rotor speed.

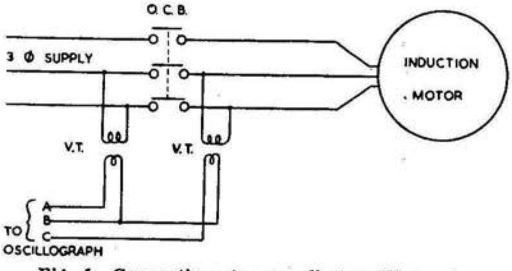

Fig. 1—Connections to recording oscillograph

The flux decays fairly slowly and the decay can be followed by recording the voltage induced by it in the stator winding by means of an oscillograph.

Fig. 1 shows how an oscillograph was connected to give the traces shown in the figures that follow. Connections to A and B gives the supply voltage, B and C gives the voltage on the induction motor stator, and to A and C gives the voltage across the circuit-breaker. This last voltage will depend on the magnitudes of the voltages AB and BC and on the phase angle between them. While the breaker is closed AB is equal to BC and AC is zero.

Fig. 2 is an oscillograph record of these three voltages, taken on a generator stator air fan motor rated at 113 h.p., 3 300 volts, 985 r.p.m. The air dampers on the fan were closed so that the fan was lightly loaded and its deceleration on being switched out was consequently small. The top trace is the voltage BC across the motor and it shows how this voltage decays. The centre trace is the voltage AC across the breaker and the

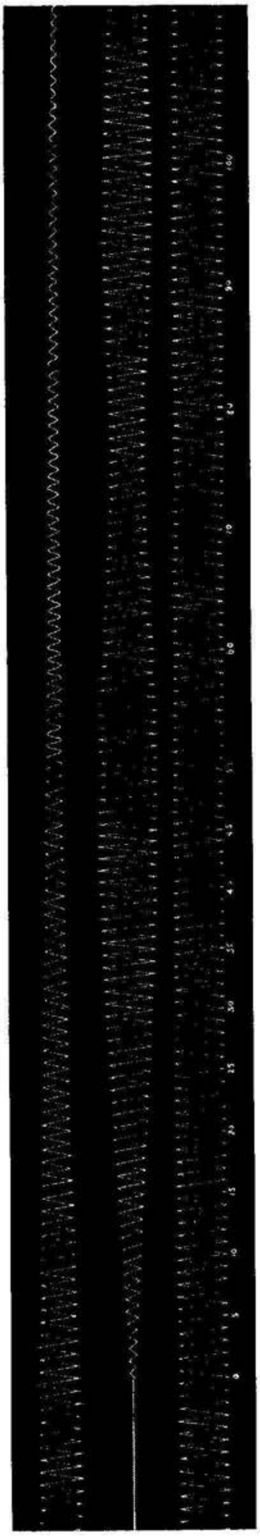

Fig. 2

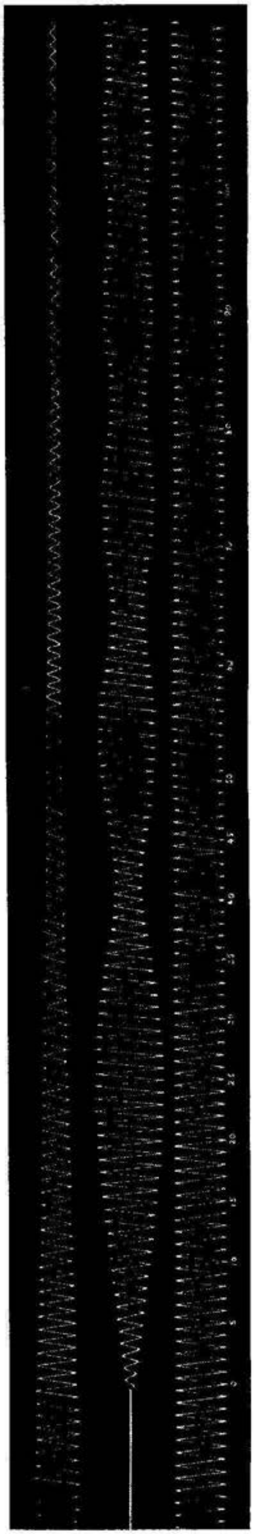

Fig. 3

Fig. 4

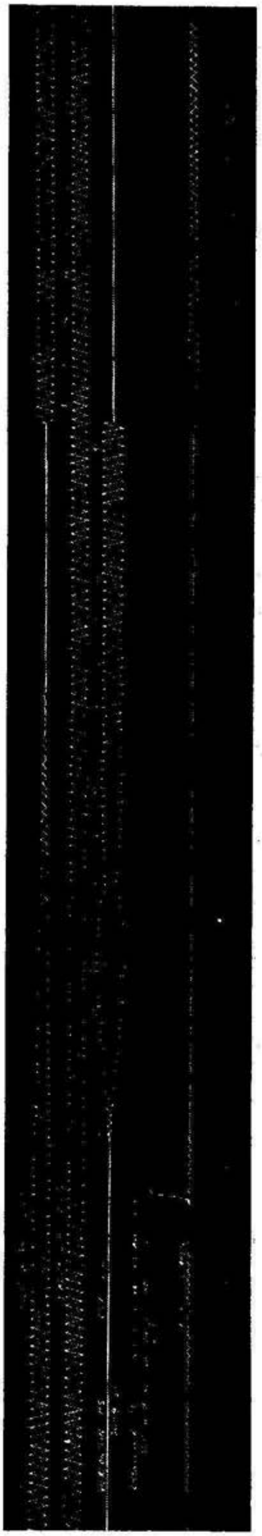

Fig. 5

bottom trace is the constant supply voltage *AB*. The time constant of the voltage decay is about 1·1 seconds. After 2 seconds the voltage has only dropped to 15 per cent of its initial value. After about 0·9 seconds the motor voltage has dropped back in phase by 180° relative to the supply voltage and the voltage across the circuit-breaker is the sum of the two voltages and in this case equal to about 130 per cent of the supply voltage.

The deceleration of the motor is more noticeable in Fig. 3, which was taken on the same machine as for Fig. 2. In this case the air dampers were open so that the motor was running at full load. The rate of decay is about the same as in the unloaded case, but the phase angle varies much more rapidly and after 0·46 seconds or 23 cycles the voltage has dropped back by 180° and the voltage across the breaker is 160 per cent of the supply voltage. The deceleration of the machine can be studied by observing the nodes and maxima of the envelope of the difference voltage.

Fig. 4 is a trace taken in the same way on a turbine condenser circulating water pump motor of 720 h.p., 3 300 volts, 594 r.p.m. In contrast with the fan a pump has a low inertia and decelerates rapidly. This is strikingly evident from the centre trace of Fig. 4. After nine cycles the voltage across the circuit-breaker has risen to 173 per cent of the supply voltage. Due to remanence of the rotor iron the rotor flux does not disappear completely while the motor is running down and the author has been told that the magnetic poles can still be detected on an induction-motor rotor when it is taken out of a machine after having been in service. Some voltage will therefore still be generated as long as the rotor turns. The magnitude of this voltage will be proportional to the speed of the rotor and the value of the flux.

Fig. 5 shows the voltage decay on a busbar in a power station which feeds a whole bank of induction motors. These were the generator and boiler auxiliaries associated with a 30-MW generator, i.e. about a dozen large and small motors totalling about 2 000 h.p. The voltage across the circuit-breaker is shown by the third trace from the top. The bottom three traces are those of the supply currents. We have here motors of different rates of decelleration and it is evident that the high-inertia machines would act as generators and the others as motors as long as voltage were maintained on the common busbars. There would therefore be asynchronous generators and motors for this time. The rate of voltage decay is much higher, having a time constant of about half of what it was for the single motors. The voltage also disappears completely in about 55 cycles. Across the breaker the voltage rises to 160 per cent of the supply voltage in about 20 cycles.

The voltage which appears across the circuit-breaker after it is opened is of great significance in induction-motor operation. If the circuit-breaker is reclosed shortly after it has been opened the flux conditions in the motor are forced to change from what they were at the instant before closing to those required by the new voltage applied. The change is proportional to the voltage across the circuit-breaker at the instant before reclosing. If this voltage is considerably more than the normal design voltage of the motor, its iron circuit will be momentarily saturated and very large magnetizing currents will flow. Currents of the order of fourteen times full-load current have been recorded. These currents may last only a few cycles but they impose very large mechanical forces on the machine. These may injure the motor windings or damage keyways, couplings or bearings either of the motor itself or of the equipment driven by it.

The high currents can be encountered during star/delta starting at the instant of change-over, and also at power stations when the supply to the station auxiliaries is changed over from the station auxiliary transformer to the generator auxiliary unit transformer. A much less severe transition is obtained, despite the drop in motor speed, if the voltage on the motor is allowed to decay before the supply is re-applied. A delay of about one second is normally adequate.

The author wishes to express his thanks to the Electricity Supply Commission–Rand Undertaking for permission to publish the oscillograms and to his associates for help in taking them.

DISCUSSION

J. T. ALLAN (Past President): It gives me great pleasure to join, once again, in the discussion of this important phenomena. It is one we are apt to overlook, so the present item is of very great technical interest. It deserves careful consideration by all users of induction motors and their control gear.

About fifteen years ago I was called in, as a consultant, to investigate the breakdown of a number of large induction motors. It was obvious that the stator windings had been subjected to very severe electromagnetic forces. The windings were badly distorted and in some cases torn apart. These motors had been in use for some years without trouble when they started to breakdown one after the other. The only new factor which could be located was an increase in busbar capacity—permitting heavier faults and ensuring better voltage regulation. This did not seem an adequate explanation of the epidemic unless some inherent fault in the system of starting had been camouflaged by bad regulation.

A theory of maintained magnetic field, rotating at rotor speed, was propounded. Thus, closing the switch in the run position was equivalent to synchronizing two alternators without using a synchronoscope. Under the worst conditions the voltages were 180° out of phase, and one machine required also to be accelerated to the supply frequency. I suggest converting the simple change-over switch to a group of switches giving an unbroken change-over (i.e. the Korndorffer system). This was carried out by Mr Badham with complete success. A report, however, was sent overseas and a detailed investigation carried out. The results were communicated to the Institute by Mr Hoseason. (See *Transactions*, Feb. 1939, pages 46 to 49.)

While this investigation deals essentially with the troubles associated with change-over switches, the data obtained, in confirmation of the theory, applies equally well to any interruption of the supply to the stator of an induction motor. The author conservatively mentions 14 times full load as a possible transient. Hoseason's figures show that it can be much greater than this—say 20 to 30 times!

The author has in the tests associated with Fig. 5, brought attention to bear on the vexed question of leaving machines connected to the busbars during an interruption of supply. It is common power station practice to latch-in the contactors feeding essential auxiliaries. This ensures their immediate restarting on restitution of the supply. The same thing can happen in the case of starters which have been provided with a time-delay on the voltage release if automatic reclosure is adopted on the supply network. One of the worst cases of the misuse of latching that I have encountered is that of a municipality which insists on latched-in star-delta starters but will not permit direct-on-line starting!

Referring to the author's remarks regarding rotor poles being detected after withdrawal, I have experienced this but the poles are very weak. Quite strong poles can be detected in the air gap before withdrawal. The difference is due to the large demagnetizing effect of the long air gap produced on removing the rotor. This phenomena is very clearly demonstrated in the theory of permanent magnets as generally accepted.

The next point I would like to discuss is a purely academic one, namely that of time constants, but it may suggest further research. It is not clear whether the author has separated the electrical and mechanical constants or considered how these vary as the machine runs down. A simple comparison of the mechanical and electrical cases is given below. Although perhaps this is not in the usual units, it will serve to show the close analogy between the two cases.

ELECTRICAL

R = Volts per ampere

= Volts per coulomb per sec

L = Volts per ampere per sec

= Volts per coulomb per sec²

$$T_{CE} = \frac{L}{R} \text{ seconds}$$

MECHANICAL (Rotational)

T_R = Torque per unit velocity

= Torque per radian per sec

I_R = Torque per unit acceleration

= Torque per radian per sec²

$$T_{CM} = \frac{I_R}{T_R} \text{ seconds}$$

In each case T_C is obtained from the reciprocal of the slope of the tangent to the curve showing the decay of the quantity measured to a time base. Alternatively it is a measure of the ratio of the energy storing capacity to the energy dissipating capacity for a particular state of flow of electricity or velocity of a machine. In the mechanical case the inertia is a quantity depending on the dimensions of the equipment and therefore a constant. The torque required to maintain the speed, or the torque producing deceleration, varies with the speed since it is compounded of the torque required by the load, friction, windage and various losses (for example, the generation of currents in closed paths in the stator). In the electrical case, the induction is not a constant but depends on the value of the current—linkage per ampere depend on the magnetization current. The resistance of the electrical circuit is normally constant but need not be strictly so, since all losses supplied directly from the electric circuit must be included in finding the effective value of R. It is certainly not the value measured by D.C. Thus both the mechanical and electrical time 'constants' are variable and should be plotted against speed and/or current in the rotor circuit. The two are inter-dependent since the losses supplied mechanically depend in part on the flux crossing the air gap which in turn depends on the rotor current. With a slip ring motor the rotor current can be measured. It is, of course, D.C. Graphical differentiation of the oscillograph record of this current shows how the time constant varies. Similarly the a.c. voltage generated in the stator divided by the speed gives a measure of the flux crossing the air gap and allows it to be studied. At slow speeds this is difficult to do accurately, since two quantities, which have to be scaled, are used. However, it will demonstrate that the flux tends to a constant value which is definitely not zero. The speed plot either obtained from the frequency, or preferably by an electric tachometer, when differentiated gives the mechanical time 'constant' and its variation.

Finally, returning to the practical issue, how can these switching peaks be eliminated or reduced to safe values? The case of the auto-transformer has already been mentioned. Peaks are reduced by never disconnecting the stator winding during starting. The case of the star-delta starter is somewhat different since the starting voltage is low, but on the other hand the running voltage is out of phase, quite apart from any slipping of the rotor field. Transients here are seldom more than three times the switch-on values, say from 6 to 10 times full load, which is well within the capacity of a normal motor. For special cases the Wauchope starter can be used. This provides resistance links to prevent interruption of supply during transition from star to delta.

The case of interruption of supply and reclosure by an automatic switch is similar to the auto-transformer case but more severe since the initial voltage is the supply voltage. The author has shown the effect of a group of small motors on the rate of decay of voltage of the group. This points to at least one method of dissipating the energy quickly.

In general, it can be said that, if it is desired to reduce the machine voltage quickly so as to provide a normal restart, there are essentially only three methods of approach. Firstly, the motor or group of motors must decelerate rapidly; secondly, the energy in the magnetic field must be dissipated rapidly by using it to produce losses or drive other motors (i.e. through a stator circuit or circuits); thirdly, the field can be made to collapse by opening the rotor circuit and so breaking the current which would maintain it.

The first of these might be achieved by mechanical breaking or by including machines driving suitable loads. The second might be achieved by short-circuiting the stator, preferably through a suitable resistance. The third requires a field-discharge resistance and switch, connected in the rotor circuit and arranged to open automatically. None of these schemes are easy to apply, but I give them as a basis for further thought.

This is indeed a fascinating subject and I again take this opportunity of thanking the author for raising it and congratulate him on his clearly stated and interesting results. This is the type of contribution to the proceedings of the Institute which I feel are most welcome as showing a truly enquiring spirit among our members which will lead to important new developments.

Automatic power factor correction at Oranjemund

By the late J. K. GILLETT (Member)

The natural power factor of the electrical distribution system in that fantastic land served by the Oranjemund Power Station is a mere 0·5. There are a variety of good reasons why this figure should be so abysmally low, but the two chief causes are the persistent longevity of some of the old motors with large air gaps, and the necessity of having motors which occasionally, depending on weather conditions, have to operate at full load, but more often loaf.

By using an antiquated 500-volt 2 500-kVA rotary condenser that was on the property, it was originally possible to operate the power station at unity power factor. This was apparently satisfactory whilst the load was reasonably small, but to cope with new field plant constantly coming into service a second rotary was unearthed on the mine. This unit, however, presented something of a problem as it had no pony motor or starting transformer and the pristine operating procedure of switching it direct on to the system appears, from eyewitness accounts, to have produced some rather spectacular system disturbances ; the chances were about equal that it either pulled into step or shut the power station down. Efforts to persuade several manufacturers to design a new pony motor for the machine proving abortive, some alternative had to be considered.

It was about this time that some inquisitive busybody put in modern metering gear on the running rotary, whereupon it was shockingly disclosed that the machine required 90 kW to run it and used 50 000 units per month, thus costing the mine at that time something like £8 000 a year.

Eventually, it was decided to purchase 500-volt 3-phase static condensers in units of about 100 kVA, each unit to be controlled by a standard contactor. However, this step made it imperative to install some method of regulating the amount of corrective capacity connected on to the system dependent upon the amount of field plant in operation. As each of the many 30 000/500-volt substations, which extend over a stretch of the Skeleton Coast about 50 miles long, houses one or maybe two 250-kVA transformers it was decided to switch the 100-kVA condenser groups on to the substation busbars. When a field plant is started up each day the contactor controlling the condenser group is automatically closed from the auxiliary contacts on one of the switches of an item of the plant. On shutting down the plant the condenser group is switched off the system, and hence there results a simple inexpensive form of power factor control which is quite independent of the degree of skill—or otherwise—of the plant operatives. The system power-factor to-day runs at approximately 0·9.

One of the interesting sidelights of this condenser switching scheme is the behaviour of the contactors at zero power factor. When purchasing these particular contactors, which incorporate thermal overload characteristics, the onerous nature of their duties was specified. The manufacturer, however, had never carried out type testing loads with a power factor less than 0·3, and was accordingly non-committal. When the first condenser groups were installed, even the seller of the switches was incredulous at the remarkably insignificant spark occurring when switching out a condenser load of 110 amps.

This condenser installation has paid for itself in the first twelve months of operation.

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