

# JOURNAL OF The British Institution of Radio Engineers

(FOUNDED IN 1925 - INCORPORATED IN 1932)

*"To promote the general advancement of and to facilitate  
the exchange of information and ideas on Radio Science."*

Vol. X (New Series) Nos. 8-9

AUGUST-SEPTEMBER 1950

## 24th ANNUAL REPORT OF THE COUNCIL OF THE INSTITUTION

*The report covers the twelve months ended March 31st, 1950. As announced on page 227 of the Journal, the Annual General Meeting will be held on September 27th, 1950.*

### INTRODUCTION

Apart from reviewing the principal events of the past year, this report outlines the main problems which the new Council will have to consider.

October 31st next is the Institution's 25th birthday—an occasion to remember that the purpose of founding the Institution was to promote "The advancement of the science and practice of radio engineering" and "the acquisition and preservation of the knowledge pertaining to the profession of a radio engineer."

Seven years after its foundation, the Institution secured incorporation under the 1929 Companies Act. By reason of its main objects, the Institution was registered as "A company limited by guarantee and not having a capital divided into shares." The Board of Trade, recognising those objects, also granted permission to dispense with the word "Limited." Incorporation actually took place on August 8th, 1932. Among those concerned in the negotiations with the Board of Trade were Mr. W. E. Miller (Vice-President) and Mr. L. H. Paddle, who has now been nominated for election as a Vice-President.

The Institution then had fewer than 400 members; they were the first to be entered into the Membership Registers which have to be kept for the information of the Board of Trade. Thereafter, each election has been recorded and the registers now provide an interesting picture of the growth of the Institution. An Institution is judged by the quality and strength of its membership and special importance is therefore attached to the Annual Reports of the Membership Committee.

The Council especially wishes this year to express its appreciation to those members who have contributed so much to the work of the various committees and who have also given so generously of their time and labours in serving the Institution. Whilst those comments apply particularly to work done in the past year, it is also an expression of thanks to all members who have found time for service to the Institution during its first 25 years.

During the 12 months ended March 31st, 1950, there have been 118 Section, Council and Committee meetings. Explanation of the work involved is again shown by reporting the principal activities of the main committees.

## PROFESSIONAL PURPOSES COMMITTEE

The Institution is now approaching the end of an epoch in its history but it is still essential that every opportunity be used to make its functions more widely known. During negotiations which were handled by the Committee in the past year it was obvious that some authorities and organizations outside the Institution were not fully aware of its purpose.

Every national or international organization encounters the problem of ensuring that its objects are properly reflected in even the most minor phase of its work. This is especially true when professional status is involved. For this reason, it must be emphasized that there has never been need, since the Institution's foundation, to alter or amend its main objects; the work of the Institution is entirely devoted to promoting intercourse between research workers and engineers, to obtaining general recognition of the importance of that work and to securing the removal of any disadvantages which impede its progress.

The problem of maintaining an essential balance between manufacturing and research engineers is often discussed. On this point alone there is a great need for co-operation between all who are concerned in defining minimum standards for the professional recognition and/or registration of engineers. Agreement on this point would be extremely helpful to all who are interested in the work of the engineer either in industry or in Government service. Inevitably the training and education of the engineer is involved and this is frequently discussed between the Membership and Education Committees.

Thus it is essential that throughout Institution activity a uniform policy must be maintained, clearly understood and supported by the membership. For that reason, the Professional Purposes Committee has, during the past year, been very closely associated with all Standing and Local Section Committees. Several joint meetings of these committees have been held and at many Mr. L. H. Bedford has presided. Indeed, his active work for the Institution has followed the tradition established by previous Presidents, notwithstanding Mr. Bedford's many commitments. The Council is glad to have this opportunity of paying tribute to his leadership.

**Relationship with other organizations.**—The proposal of UNESCO to form a "Union of international specialist engineering organizations" emphasizes the need which has been agreed in every responsible quarter for co-operation between engineering institutions. Such co-operation can be accomplished without lowering professional standards and without impairing the autonomy of each institution. Having regard to the wide interests of the members, this subject calls for the exercise of considerable prudence.

Council has agreed to continue membership of the World Engineering Conference (British Section) for a further year in order to see whether this body can play a useful part in bringing together engineering and scientific bodies, particularly those of the British Empire and English-speaking nations. The future of the W.E.C. is, of course, closely linked with the October 1950 meeting of UNESCO and the degree to which the Government and other engineering Institutions will support the proposals of the United Nations Organization.

Membership of the Parliamentary and Scientific Committee has proved to be most valuable. This organization, bringing together members of both Houses of Parliament and representatives of scientific and engineering Institutions, has had many meetings and discussions on such matters as arrangements for the Festival of Britain, the work of the British Standards Institution, technical training and education and other subjects of interest to the radio engineer. The Chairman of Council and the Secretary have been the Institution's representatives.

The Institution continues to subscribe to the British Standards Institution and during the year members have served on a number of B.S.I. Committees. Acknowledgment of the Institution's representation is contained in reports issued by that organization.

There has, however, been some discussion on the way in which the personnel of B.S.I. Committees and Panels are chosen or nominated. The Institution's point of view was communicated to the Director of the B.S.I. and resulted in a meeting between the Director and the President of the Institution.

Co-operation with the Education Committee has included the nomination of representatives

to discuss training matters with other bodies, especially the Services. Mr. W. E. Miller (Vice-President) represented the Professional Purposes Committee in discussions with the Admiralty and the Air Ministry.

From every point of view it is obviously desirable that a professional body should encourage Service membership, as well as membership of those who are professionally engaged in industrial or Government employment. Comment was made on this subject in the 1946 Annual Report and it is again dealt with in the report of the Education Committee, which also shows the Institution's membership of other organizations in the educational field.

Discussions have also taken place with the Ministry of Labour and National Service on the operation of the Technical and Scientific Register. The President, Professor H. M. Barlow and the Secretary were the Institution's representatives in these discussions.

**Honorary Membership.**—The decision of Council to confer upon Mr. Leslie McMichael (Immediate Past President) the distinction of Honorary Membership will be welcomed by the entire membership as an expression of great appreciation for his work. Throughout his long association with the industry, commencing from the earliest days of radio, Mr. McMichael has taken great interest in the work of all associations concerned with the development of radio science; the Institution is grateful for the many ways in which he has assisted its various committees, particularly during his Presidency.

**Overseas and Local Sections.**—The first proposals for the formation of a South African Section of the Institution arose from Mr. McMichael's visit to the Union and this and the proposal to form a Section(s) in India, whilst coming under the purview of the Membership Committee, have also been the concern of the Professional Purposes Committee.

Activity throughout the Sections assisted the flow of papers to the Institution and led to recommendations for the establishment of further Premiums as a means of denoting outstanding contributions. Allied to this subject is the acceptance by Council of the proposal that the Institution should now endeavour to perpetuate the names of pioneers in the development of radio science. Details have already been

announced of the arrangement to establish a Memorial Lecture to honour the work of Clerk Maxwell, the first of which will be given during the next twelve months.

Supporting the principal activity of the Programme and Papers Committee has been the development of the *Journal*. Whilst at present proving a heavy burden on finances, the *Journal* materially and usefully assists in establishing the status of the Institution. In addition to reporting meetings and publishing the papers presented to the Institution, the *Journal* has also been the medium for reporting general Institution activity—a policy which has earned the approbation of members and non-members.

**1951 Convention.**—In response to the invitation that all scientific bodies should support the Festival of Britain by arranging special activities, the Professional Purposes Committee have also been closely concerned in the plans for the 1951 Convention. Arrangements have been divided between the Papers, Technical and Professional Purposes Committees. The decision not to hold a continuous Convention but to divide it into three-day sessions spreading over the period of the Festival will have obvious advantages both to members and to visitors.

During the first 25 years of the Institution's existence, great progress has been made, in spite of many difficulties and setbacks. Whilst conditions may change, every year brings forward new opportunities for service to the membership and profession. This report shows that a very sincere attempt has been made to implement the general objects of the Institution and to enable it to make secure its proper place among the professional engineering Institutions of Great Britain and the Empire.

## MEMBERSHIP COMMITTEE

Since 1943, each Annual Report has included a detailed statement showing precisely the gain and loss in membership, as well as a note on the number of proposals considered. The principal work of the Committee during the past year is summarized in the following tables to which may be added that the number of proposals actually considered by the Committee does not include those which, in order to save time, are dealt with by the secretariat as being wholly unsuitable. In this connection the Institution received during the year a total of 1,813 enquiries regarding

membership—an increase of nearly 400 over last year. In addition, there is an increase in the amount of correspondence with intending applicants which may not become evident in membership returns for some time.

Notwithstanding losses by deaths and other causes, and without resorting to any special effort to increase the membership, the net gain for all grades during the year is 296—nearly 100 per cent. above last year's figure and the highest since 1945/6. The number of transfers to Graduateship and higher grades is also the highest for four years. These improvements in membership figures are especially noteworthy when it is remembered that during the first half

of the year there was some slackening of manufacturing activity. This resulted in a slight drop in employment returns as compared with those for the preceding two years.

**Studentship Registration.** — Whilst the Registration of Students is the immediate concern of the Education Committee, this grade is now a large and active force in the future plans of the Institution. The total number of Registered Students—now over 1,300—is even greater than the total of the Institution's pre-war membership. This first step toward professional status is based on agreement between professional Institutions on the essential preliminary training of an engineering student.

1949/50

Direct Elections

Proposals	Members	Associate Members	Associates	Companions	Graduates	Students	Total
Received ..	5	54	61	3	27	345	495
Accepted ..	3	38	52	2	31*	342	468

Transfers

Proposals	Associate Member to Member	Associate to Associate Member	Graduate to Associate Member	Graduate to Associate	Student to Associate Member	Student to Associate	Student to Graduate	Associate to Graduate	Total
Applied for ..	15	53	3	1	12	47	69	1	201
Accepted ..	6	24	3	1	5	35	77*	1	152

Reinstatements

5 Applications for Reinstatement as Associates were received and accepted.

Removals due to Resignation, Expulsion or Death

Members	Associate Members	Associates	Companions	Graduates	Students	Total
6	17	26	1	2	125	177

\* The above figures include applicants who have subsequently agreed to accept a lower grade of membership than that for which they originally applied.



These conditions are laid down by the Engineering Joint Examination Board and compliance with that Board's regulations is a necessary preliminary to registration as a student. Subsequent study and training determine the student's suitability for transfer to a higher grade and create within the Institution an ever-increasing number of properly trained radio engineers who are rightly jealous of the standing of their own professional body.

Great responsibility is involved in framing the requirements of training and in instilling a sense of pride in professional attainment. The younger member has a major part to play in finding solutions to many of the problems still to be solved in the expansion of the radio industry. For this reason he has need for a greater and wider fundamental knowledge of radio science than was, in fact, available twenty years ago. These requirements must be reflected in such schemes as the Graduateship Examination and the necessity for interchange of opinion which is fostered by membership of the Institution.

The last point is as important as the question of obtaining qualifications. Men do not unite in professional Institutions for mundane matters only, but to secure opportunity for free and creative thought. Consequently, by ever-increasing membership, both the Industry and the Institution will benefit and the latter will achieve even greater status. Proof that the Institution is developing on these lines is shown by the fact that 88 per cent. of the total membership to-day has been elected since January 1st, 1939.

Like all similar societies, the Institution is a voluntary body and relies almost entirely on the subscriptions of members for its main income. Expansion of the Institution's services, including the formation of new Sections, depends upon membership growth and the activities of existing Sections could be augmented if their grants were increased.

Corporate membership is about one-half of the total membership of the Institution, and this balance could be improved. Members are only too well aware that the need to secure greater membership does not mean any lowering of standards. Quality must still be the prime consideration and when asked to support a proposal for membership, a sponsor should ensure that the candidate will prove an asset to the Institution. This implies that the proper

attitude of the applicant is to ask himself not what he can get out of the Institution (which is no more than the embodied resultant of the wishes of himself and others with similar interests), but rather what he can do to add to the common stock.

There is similarly a responsibility on the Institution to see that new members are taking full advantage of the facilities available and are also contributing to the Institution's objects. The Committee would like to see every effort made to absorb new members into local Section activities, thus helping members to know each other and establishing new Sections wherever necessary.

Finally, on the subject of increasing membership, the Council appreciates that until last year the requirements for the non-corporate grade of Associate differed from those of other Institutions. A revision of the Associateship regulations now provides an avenue of entry for those candidates possessing the qualifications for membership but lacking appropriate examination success. As indicated in previous reports, this class of member is found in nearly all the professional engineering bodies and is one from which important contributions can be made to the future progress of our work.

**Publication of New Elections.**—The *Journal* now regularly shows all new elections and transfers to the various grades of membership, as well as personal notes of members who are serving the Institution in one way or another. Particular reference is made to the number of Honours conferred upon members during the past twelve months, which have also been featured in the *Journal*.

**Overseas Membership.**—There continues to be a welcome flow of new members from abroad, mainly the countries of the Commonwealth. Reference is made elsewhere to the provisional committee set up in South Africa, and as a result of the members' meetings, which have already been held in the Union, there has been a considerable increase in the number of enquiries received, as well as actual proposals.

During the year, representations have been made to Council advocating the formation of Sections in India. Several Indian members who have visited London have submitted proposals which might form a basis for appointing an Indian Advisory Committee, who would arrange

occasional meetings in appropriate centres throughout India. Difficulty has been, and will be, encountered in reconciling the qualifications of overseas candidates with the Institution's regulations but the appointment of Overseas Section Committees will facilitate the consideration of proposals.

**The Appointments Register.**—The appointments service, operated by the Institution under a licence granted annually by the London County Council, has been especially active during the past twelve months. A number of members have been assisted in obtaining employment which, in the majority of cases, actually means a promotion for the member. One of the most encouraging features of this service has been the very favourable commendations received from some of the largest firms in the industry regarding suitability of the applicants put forward by the Institution.

This service is, of course, operated by the Institution without payment of any fees, and some idea of its activity may be gauged from the fact that during the year bi-monthly supplements have been circulated to the members showing the type of vacancies referred to the Institution.

Members who are in a position to notify the Institution of further vacancies are invited to make full use of the Register as, particularly in the younger grades, there are a number of members anxious to improve their positions.

### EDUCATION AND EXAMINATIONS COMMITTEE

Alterations to the syllabus of the Graduateship Examination and the addition of the compulsory paper in Mathematics have already been announced in the *Journal*. These revisions have been accomplished under the chairmanship of Professor E. E. Zepler, who now retires from the committee on which he has served for five years. Professor Zepler has been nominated for election to the General Council.

The last Annual Report included a histogram showing the entries and results of twenty Graduateship Examinations up to and including November, 1948. Entries continue to rise very

steeply; for the May and November, 1949, examinations, 264 and 251 entries respectively were accepted and up to March 31st, 1950, 336 entries had been received for the May, 1950, examination.

**Examination Entries.**—The first registers kept by the Institution for examination entries are not complete, but it is known that from 1935 to December, 1949, the Institution accepted 2,455 entries for the Graduateship Examination. The Registers also show that of this number 467 satisfied the examiners in all subjects. The Institution is now accepting over 600 examination entries per year, and the entries for the May and November, 1950, examinations bring the total since 1935 to well over 3,000.

The detailed results for 1949 have already been published in the *Journal* and show that only 84 candidates qualified for election to Graduateship or higher-grade membership. Less than 50 per cent. of the candidates succeeded in obtaining a pass mark in any one subject and the attempts at Part 3 (Advanced Radio Engineering) were especially poor, resulting in only 19 per cent. of the candidates who wrote this paper in the November examination obtaining a pass mark.

**Examination Exemptions.**—As the number of entries for the Graduateship Examination increases, it is inevitable that a similar increase will be experienced in the number of applications for exemption from the entire, or part of, the Graduateship Examination. During the year the Committee considered 290 applications for exemption, compared with 247 for the previous year.

These claims for exemption are normally based on qualifications not specifically mentioned in the regulations and were dealt with by the Committee as shown in the table below.

**Examination Centres.**—During the year the examination was held at 11 centres in the British Isles and 25 centres overseas, including Australia, New Zealand, Canada, South and East Africa, Egypt, India, Pakistan, Ceylon and Malaya. In each case, arrangements were made at a Government-recognized technical college

Complete Exemption	Exemption from Parts 1, 2 and 3	Exemption from Parts 1 and 2	Exemption from Part 1	Exemption from Part 2	Exemption Wholly Refused
45	38	90	66	25	26

or a University, and the Council expresses thanks to the authorities concerned for the facilities granted to the Institution.

**Revision of Examination Syllabus.**—The introduction of Mathematics as a compulsory subject is a further step toward raising the standard of the Graduateship Examination. Also under consideration is the suggestion that the Physics section be replaced by two separate papers, each of three hours. Further notice will be given regarding this alteration and meanwhile, from November, 1950, Part I will comprise one three-hour paper instead of two one and a half-hour papers, but the present syllabus will remain unaltered.

**Examiners.**—During the year 16 examiners were appointed to prepare 20 papers and they were assisted by the Examinations Committee. Their duties have been made more exacting by the increasing number of entries and the Council wishes to thank the examiners and the Committee for the care and attention which they have so loyally devoted to the work entrusted to them.

**Prize Awards.**—In order of merit the Council has awarded the examination prizes for 1949 as follows :—

*President's Prize.*

To Henry Arnold Wolff (now an Associate Member) of Launceston, Tasmania.

*S. R. Walker Prize.*

To Alan David Phillips (Student) of Manchester.

*Electronic Measurements Prize.*

To John Francis Sayers (now a Graduate) of Barnehurst, Kent.

*Audio Frequency Engineering Prize.*

To Khadri Samachar Sreenivas Acharya, M.Sc. (now a Graduate), of Trichinopoly, India.

There being no candidate who passed the entire examination whilst serving in H.M. Forces, the Mountbatten Medal was withheld.

**Representation on Other Committees.**—The Institution continues to be represented on the City and Guilds Advisory Committee on Telecommunications in the persons of Professor E. E. Zepler and the Secretary. The work of the City and Guilds of London Institute in encouraging training in radio engineering and in setting examinations is well known. Indeed,

they were the first body in this country to establish examinations in radio engineering and the first Advisory Committee for this purpose was set up in 1924.

The Council is glad to have this opportunity of congratulating the City and Guilds on the fine record it has established. Reference to these examinations was detailed in the 1944/5 Annual Report, to which can now be added the following facts :—

- (1) Beginning with 46 entries for the two grades of Radio Communication examinations in 1924, the increase reached a new record of 5,274 candidates in all the radio examinations held during 1950 (excluding candidates sitting the Telecommunications Principles Examination).
- (2) A total of 48,245 candidates have sat the radio examinations of the City and Guilds during the last 26 years. The total attempting, in the same period, the Final or Grade 3 examination is 7,331.
- (3) 11.5 per cent. of the candidates sitting Grade 3 or its previous equivalent obtained 1st class passes, but it is interesting to note the close comparison with the Graduateship Examination results in that during the past 5 years this percentage has dropped to 7.5 per cent.\*
- (4) Since the introduction, in 1948, of the Grade 4 examination in radio, 399 candidates have sat and 42 have obtained 1st class passes.

Thus, the experiences of the City and Guilds of London Institute are worthy of particular attention because, although very much larger figures are involved, the results bear very close comparison with the histogram published in the last Annual Report. Both sets of figures show that an increasing number of students continue to qualify for advancement by directly studying courses purposely designed to cover radio engineering practice.

\* Under the revised 1948 regulations the Institution grants exemption from the entire Graduateship Examination to candidates holding a 1st Class Certificate in the Grade 3 examination, plus a 1st Class Pass in the Telecommunications Principles Grade 4. Previously, a 1st Class Pass in the old Grade 3 examination was required with the addition of the two examinations in Technical Electricity. The total number of candidates obtaining the appropriate City and Guilds 1st Class Certificates during the past 26 years is 849.

The Institution was first invited to serve on the Advisory Committee in 1935 and continues to appreciate the value not only of its representation, but of the contribution made by the City and Guilds of London Institute to the whole subject of radio training.

**Advisory Committee on Radio Service Work.**—In addition to association with the City and Guilds of London Institute through the Radio Trades Examination Board, the Institution also has a direct representation on the Radio Service Work Advisory Committee, this year's representative being Mr. G. A. Taylor, a past Chairman of the Education Committee.

**Other Representation.**—Various members of the Education Committee and Membership Committee also represented the Institution in discussions with the Naval Electrical Branch of the Admiralty and the Technical Directorate of the Air Ministry. These negotiations were finally completed during the year under review and details were published in the April 1950 Journal.

**Radio Trades Examination Board.**—Older members will recall that in order to promote interest in the desirability of securing reasonable standards of Service Work, the Institution initiated in 1935 a Radio Servicing Certificate obtainable by examination held under the Institution's auspices. There followed in 1938 the first of the City and Guilds examinations in Radio Service Work. Finally, the Institution convened meetings with the Radio Manufacturers Association, the Scottish Radio Retailers' Association and the Radio and Television Retailers' Association which led to the formation, in 1941, of the Radio Trades Examination Board. Subsequently, in 1947, arrangements were made whereby the R.T.E.B. Certificate was awarded to successful candidates by means of examination conducted jointly by the City and Guilds of London Institute and the Radio Trades Examination Board. 161 candidates entered for the May 1949 examination and 264 entered for the 1950 examination. For the purpose of record and by agreement with the Radio Trades Examination Board, examination results are published in the *Brit.I.R.E. Journal* and provide useful information for members interested in training schemes, as well as for all engineers concerned with servicing arrangements.

Further testimony to the advantages of the present scheme of holding the examination is evident from the fact that during the past 12 months final details were completed for holding the first Television Servicing Certificate Examination. This was confined to the London area and admission restricted to those who had already passed the R.T.E.B. Radio Servicing Certificate Examination. Thirty candidates were admitted, which has given invaluable experience to the Board who contemplate a considerable increase in the number of entries when it is possible to hold the examination in other centres.

The need for encouraging training and examination is evidenced by the remarkable fact that at the end of 1949 over a quarter of a million television sets were licensed in Great Britain compared with the twenty thousand in use when the post-war programme began.

Many members of the Institution have given assistance in holding the Board's examinations by acting as local examiners, in addition to those members who serve on the Examinations Committee of the Board under the chairmanship of Mr. S. A. Hurren, O.B.E., M.C. (a Past President of the Institution).

The Radio Industry Council! gives considerable support to the scheme, especially by loaning radio and television receivers for the purpose of the practical examinations.

Approved courses for the Radio Servicing Certificate Examination are held at approximately 60 technical colleges throughout the British Isles but one of the difficulties experienced is obtaining suitably qualified part-time teachers. Those engaged in radio service work would seem to be the most suitable but unfortunately they lack, in general, the teaching experience. On the other hand experienced teachers have an insufficient knowledge of radio servicing practice. For these reasons the Ministry of Education, in conjunction with the Radio Industry Council, are organizing a short course for technical college teachers of radio servicing at the Regent Street Polytechnic.

Despite the large increase in entries the Board continues to be subsidized by the constituent bodies, namely the Radio Industry Council, the Radio and Television Retailers' Association, the Scottish Radio Retailers' Association and the Institution. The Institution also provides the secretarial facilities for the Board.



**Technical Colleges.**—Finally, the Committee reports that in addition to granting facilities for examinations, considerable co-operation has been afforded by many technical colleges. The Institution's relationship with these colleges and Universities has never been so widespread as now and many members are assisting to overcome the present shortage of qualified lecturers by giving part-time service to technical colleges.

## PROGRAMME AND PAPERS COMMITTEE

Since the last report Mr. G. L. Hamburger has been Chairman of the Committee, which now comprises 12 corporate members.

The principal work of the Committee has been to examine papers submitted by members and others and to secure a proper balance of material published in the *Journal*. Although the scope should be wider, the subjects discussed at meetings and/or published in the *Journal* have included magnetic amplifiers, broadcasting, radar, television, industrial electronics, electroencephalography, frequency modulation, aerial design, valve design, instrumentation and electrical problems including transformer design.

Apart from papers specially invited, 40 papers have been offered, but of these 12 have had to be rejected as unsuitable, either because they were too elementary in nature, or because the subject-matter was fundamentally unsound or too well known to justify recapitulation. In other cases where the subject matter would have been satisfactory, the presentation was poor. All Institutions have an insatiable appetite for papers and bearing in mind the commitments of the 1951 Convention, Council emphasizes the desirability of more members contributing useful information or complete papers. In particular, the Committee would welcome a series of papers which would show the present state of the art of radio manufacture with indication as to how progress and further efficiency might be effected.

As in the past the Committee has discussed with authors the best method of preparing papers and has found that this service is appreciated.

Such assistance, as well as the planning of future meetings and Conventions, has necessitated the appointment of a wider panel of readers to assist, by reason of their specialized knowledge, in assessing the suitability of papers submitted to the Institution. The response to

such invitations has been most generous and sincere thanks are due to those readers who have undertaken this onerous task and especially to those who are not members of the Institution. Their contribution in the form of constructive comment on papers does much to assist the authors, whilst also ensuring accuracy and valuable reference in the papers which are finally published in the *Journal*.

The Committee's main contribution to the arrangements for the 1951 Convention has been to select subjects and obtain the co-operation of competent authors of papers. More detailed information regarding the final arrangements is given in the report of the Technical Committee.

**1949/50 Session.**—Only one Section had less than seven meetings during the year and in addition to the normal monthly meetings the Scottish Section held its first social function last September.

**Acknowledgments.**—The Council wishes to express its indebtedness to all those who delivered papers during the year and to the firms who made the services of the members of their staff available for this work. Without such co-operation it would have been difficult to maintain the high standard of Section meetings.

Thanks are also expressed to the following authorities for providing accommodation for meetings :—

*London School of Hygiene and Tropical Medicine*

*Institution of Engineers and Shipbuilders, Glasgow*

*Heriot-Watt College, Edinburgh*

*Institution of Mining Engineers, Newcastle-on-Tyne*

*Coventry Technical College*

*Manchester College of Technology*

*Wolverhampton and Staffordshire Technical College*

The Institution has become accustomed to, but is no less appreciative of, the space devoted to reporting Institution activities in *The Wireless Engineer*, *Wireless World*, *Electronic Engineering*, *Wireless and Electrical Trader*, and *Electrical and Radio Trading*. Other technical and scientific journals have also been frequently reporting special activities of the Institution.

**Premiums.**—During the year, Sir Louis Sterling (Past President) expressed the wish that there should be some recognition of outstanding papers published in the *Journal* concerned with television technique. Sir Louis Sterling very kindly provided the finances for awarding a Premium and consented to this new award being named after him.

There were, therefore, five Premiums available and Council congratulates the following authors whose papers qualified for these awards, as follows :—

Awarded the Senior Premium—The Clerk Maxwell : E. H. Frost-Smith, B.A., for his paper on

*An Experimental Study of the Magnetic Amplifier and the Effects of Supply Frequency on Performance.*

The Heinrich-Hertz Premium : To J. B. Birks, Ph.D., B.A., for his paper on

*The Physical Applications of Microwaves.*

The Marconi Premium : To R. Keitley, B.Sc., for his paper on

*Some Possibilities of Heating by Centimetric Power.*

The Louis Sterling Premium : To A. W. Keen (Associate Member) for his paper on

*The Integration Method of Linearizing Exponential Waveforms.*

In view of the terms of reference governing the Norman Partridge Memorial Award, Council regrets that it has not been possible to award this premium for 1949.

**Preparation of Material for Verbal Presentation or Publication in the Journal.**—The Committee is still engaged on revising the pamphlet bearing the above title and in this connection is discussing with the Technical Committee the possible publication of a report giving the Institution's recommendations on the use of symbols and abbreviations to be adopted in publications. Much of this is concerned with the various recommendations issued by the British Standards Institution to which further reference is made under the report of the Technical Committee.

**Local Sections.**—As indicated in the 1947 report, new arrangements were made with the Local Section Committees in the matter of financial grants. This was part of the Council's plan to give as much autonomy as possible to Local Sections. The second year of these arrangements has proved of value to the membership generally as well as the desire of Local Section Committees to co-operate as much as possible in the development of Institution policy. Indeed, the Council has been strengthened by the operation of the Article appointing Chairmen of Local Sections as ex-officio members of the General Council.

The Papers Committee continues to be concerned with arrangements for technical meetings of the Sections and improving the relationship between those Sections and the main Committee, especially in the matter of obtaining useful reports of the Local Section meetings suitable for inclusion in the *Journal*. Branch Committees have a tedious job and upon their voluntary efforts largely depends the success of the Institution. The work that is done assists the individual member and brings him into closer contact with the membership and the whole of the Institution's activities. Much of this must be done by the members of the Local Section Committees whose voluntary work must not be strained and requires division of duties. For this purpose, as the membership of the Local Sections grows, alterations to the By-Laws will be suggested in order to permit a larger number of members to serve on these Committees.

Nearly every Section is now circulating to its members an annual report of activities. When printing and other conditions permit, it is hoped to make a regular feature of these reports in the *Journal*. During 1951 quarterly summaries of the membership of each section will be published. These figures together with the attendance at local meetings will provide members and Committees with valuable data on the suitability of subjects discussed at Section meetings.

**The Journal.**—Whilst the activities of each committee of the Institution contribute in some way to the published proceedings, the Papers Committee has the greatest responsibility for recommending the material to be published. Since 1926 a Papers or similar committee has been appointed by the Council to advise on matters for *Journal* publication—although as older members will recall, these publications of

the Institution were issued as Proceedings until 1939 when the present series of *Journals* commenced.

Wartime conditions did not interrupt publication of the *Journal*, although for many reasons it was not possible to publish more frequently than bi-monthly. Since the end of the war, the *Journal* has been issued more often and during 1949 there were 12 monthly parts. An interesting commentary on the work of the Papers Committee is shown by the fact that the 1949 volume comprised 464 pages of which 399 were devoted to technical text—an increase of 130 over 1948 and the largest since the Institution first issued such publications.

Notwithstanding the considerable difficulties which have been generally experienced in the printing and paper industry, the *Journal* was published regularly and within a few days of the agreed date of publication. Printing difficulties have, of course, been reflected in costs and this is dealt with by the Finance Committee. Nevertheless, the new format and paper, which has enabled a better reproduction of diagrams and other illustrations, has been very favourably received by the membership and increases the value of the *Journal*.

The Committee believes that some members would like to contribute to the Proceedings but feel that they cannot produce a complete paper. This may be either because they have not the time or because the paper they have in mind would not contain enough material to form a paper of the normal length for publication. The Committee is now prepared to accept contributions of this nature for publication provided that they are of the requisite technical standard: they are being published under the heading of "Contributions." In addition, comments on papers previously published in the *Journal* will be included in this section.

The need for papers is as great as ever and in particular the Committee are very anxious to increase the supply of "engineering" papers dealing with the design details and production of specific equipment.

**Year Book.**—Publication of a new Year Book has been delayed because of the printing difficulties already mentioned, but the Council is hopeful that this useful publication will be ready for distribution at the end of 1950.

## LIBRARY COMMITTEE

Members are making greater use of the Library and the functions of this department may be summarized as follows:—

1. The acquisition of material (books, pamphlets, periodicals, press cuttings, etc.) either by purchase or by gift.
2. The loaning of this material to members.
3. The recording of information contained in the material mentioned above and available elsewhere, in such a form that it is readily accessible to members.

The first of these items is obviously the most important as without stock there could be no library service whatsoever. This "raw material" of knowledge and information is very costly. There has never been a valuation of the library and, therefore, the figure shown in the Balance Sheet includes the actual expenditure since 1942.

Visitors to 9 Bedford Square are aware that the main part of the Library is housed in one of the principal rooms in the Institution, and contains nearly 700 books which form the lending library and nearly 400 other books which mainly comprise a reference library. This room is frequently used by members. In addition, a number of the older reference books are housed in another room.

Facilities are also available for members to see some 75 journals, magazines and trade papers which are made available either by subscription, free copies or exchange. They include many American publications and several foreign journals in different languages.

**Borrowing Facilities.**—During the year, 392 volumes were sent by post on loan to members. The cost of packaging and postage is increasing, but the majority of members refund the postage.

These borrowing services are freely available to members throughout the United Kingdom. Members are invited to enquire for any books which they consider should be in the library, provided that they deal with subjects covered by the Institution's objects. If the book is not already in the catalogue, it will be purchased or arrangements made for its loan through one of the several scientific libraries to which the Institution now subscribes. Books requested are, if available, despatched within twenty-four hours. Books are loaned for one month and may

be renewed at the end of this period unless required by another member. The cost to the borrower is only that of returning a receipt for the book as soon as he receives it, and the postage on the book itself when it is finally returned to the Library. Usually, two books may be loaned to a member at a time.

Loans continue to be made to other Institutions, Government Departments, manufacturers and similar bodies, which is, in itself, a measure of the esteem in which the Institution is now held.

The present system of loaning books is the best that can be arranged for the time being, although consideration has been given to the possibility of creating further facilities for those members who are unable to visit the Library in Bedford Square. Section Committees have explored the possibility of using local library services to which the Institution subscribes for the benefit of Section members. Usually, however, it is found that those schemes operate such a small number of books likely to be of use to members that a far more satisfactory service can be given by increasing the Institution's own Library.

**Library Catalogue.**—Copies of the Library Catalogue are still available. Preparatory to independent valuation a new index of all books is being prepared under the supervision of the Committee, which will also facilitate the compilation of a catalogue. The Committee have already recommended to the Council that the revised catalogue be published in loose-leaf form so that it can be kept up to date by the issue of supplements.

This work will also indicate shortages of books in any particular branch of radio engineering. The Committee appreciates that, although the Library is far from complete, it is now able to comply with most of the requests made. There is, however, every need to build up this side of the Institution's activity so that it does become a well-known and valuable asset in serving the needs of members.

**Gifts.**—Some 200 books and back copies of journals were given to the Library during the year. Thanks are expressed especially to Wing Commander J. W. Whitehead (Member), Mrs. W. A. Beatty and Mrs. W. Hargreaves.

**Purchasing.**—The shortage of book supplies in certain subjects has been largely overcome,

but, in general, the purchase of all books is governed by the policy of catering for the membership of the Institution which broadly provides two distinct types of borrowers :—

- (a) Students who are taking the examination of the Institution and who require a comprehensive selection of books covering all the subjects laid down in the syllabus. This section of the Library is very extensive.
- (b) Members who require books and information for their everyday work and whose needs represent a far more varied requirement than the first category.

Purchases for the Library may therefore be catalogued as follows :—

- (1) Basic technical works of a general nature on mathematics, physics, general radio engineering, etc.
- (2) The more recent technical works dealing specifically with various branches of radio engineering and in many cases disclosing new information.
- (3) Management and economics works where they have a definite bearing on or interest for those who are engaged in management in the industry.
- (4) Books on maintenance and servicing.
- (5) Official publications dealing with any of the above topics and certain other textbooks which, whilst outside the general field of radio engineering, may be required by the membership.

Thus, the object of the Institution's Library is not only to provide just a lending service but to be of assistance to the student who is preparing for examination and to supply older members with information which may not be readily available from other sources.

**General Information.**—The recording and dissemination of information is considered to be one of the more important functions of an Institution Library.

Very frequently the Library receives requests for advice and information on literature available on a specialized branch of a single subject. The Universal Decimal Classification and the correct titling of books and technical articles may normally enable such enquiries to be quickly answered. In the indexes now being prepared, the suitability of the reference number and



title will be considered in relation to the subject matter of the article or book. Information on new additions will be especially recorded in this way. Thus a further service will be rendered to members on the same lines as the report on Electronic Aids to Industry which was prepared by the Technical Committee and published in the December 1949 *Journal*.

The records being maintained are extremely time-absorbing but progress is steadily being made and the Library is gradually becoming more and more in a position to answer detailed enquiries. During the year under review these enquiries have not been confined to books or to the availability of literature on a specific subject. Technical enquiries have also covered a wide range of subjects from regulations on the use of radio equipment to work of a development or research character which can be undertaken by members or other organizations known to the Institution. This side of the Institution's work has tended to be overlooked; members can always make enquiries which the Librarian and other members of the staff will endeavour to answer from the sources of information available to them.

**Abstracts and Reviews.**—An index, including abstracts, to the principal papers published in the *Brit.I.R.E. Journal* from 1939 to 1949 inclusive, was published in January last.

A record number of books were reviewed in the *Journal* during the year, and from comments received it is apparent that the reviews are appreciated by all the readers. Thanks are due to the publishers who invite publication of such reviews and especially to the many members who have collaborated in providing this service.

Considerable progress has been made in building up all these services for the use of the membership in particular, notwithstanding shortage of space, time and staff.

### TECHNICAL COMMITTEE

The year's principal report of the Technical Committee was that on "Electronic Aids to Industry." Work continues on this subject with a view to issuing a supplementary report and to the promotion of papers describing specialized electronic aids.

Such work facilitates ready reference not only to literature on specialized branches, but also

to accomplishment in the manufacturing sense. It will be appreciated that the compilation of such references depends very largely on initial work which enables the Committee to draw from its membership individual contributions. Members of the Institution who do not serve on the Technical Committee have made, and can make still further useful contributions. Time and staff facilities have, however, to be taken into consideration. The Committee has, therefore, recommended that the Council should appoint, in the very near future, a full-time technical officer who will not only assist in the work of the Technical Committee but also serve the various sub-committees which are frequently appointed.

Preparing the type of report useful to the membership involves consideration of those papers which are normally referred to the Papers Committee, as well as noting other literature acquired under the ægis of the Library Committee. There have, therefore, been discussions with these committees regarding subjects which can be usefully covered in special reports, as well as prompting the writing of new material which has not hitherto been published.

**The Beveridge Committee.**—After consultation with the Council it was agreed that the Institution should not give any evidence to the Beveridge Committee which is now summarizing its recommendations to the Government on the renewal of the B.B.C. Charter.

On the question of release of technical information, it is agreed that considerable contributions are made to radio literature by B.B.C. engineers. A number of factors which might promote closer understanding between the Institution and the B.B.C. are, however, being negotiated by the General Council.

**Codes of Practice.**—Prompted by members' suggestions, the Committee examined the possibility of preparing draft or suggested "Codes of Practice," not only on manufacturing technique, but with particular reference to the use and installation of industrial apparatus. Such a draft would have to take into account the work already done on the subject, including recommendations published, for example, in various pamphlets of the British Standards Institution.

The Committee is, therefore, submitting to Council a draft of a paper entitled "Good Engineering Practice" which will have the merit of including all references to existing codes of practice or recommendations likely to be of value to the radio engineer.

**British Standards Institution.**—A point not previously mentioned in Annual Reports is the practice of the Committee to meet during the year at least some of the members who have been nominated to serve on B.S.I. Committees. Experience has shown that the ensuing discussions are useful to the Committee and to the representative, by ensuring that the Institution does not duplicate work done elsewhere, and in giving opinions likely to be of service to the B.S.I. Committee.

Whilst it may be difficult always to determine to what extent standardization can be applied, particularly in a new and growing industry, there is a wide range of subjects, including that of nomenclature and symbols, on which every engineer would like to have agreement. Apart from national considerations, there is an increasing measure of co-operation with organizations abroad, and the subject of servicing and maintenance overseas also provides argument for some measure of international agreement. Many considerations are involved which might well be the subject of a discussion meeting, but, in general, the Council agrees with the desirability of the functions of a standards institution as evidenced by its contributions to B.S.I., the selection of suitable nominees, and regular mention of B.S.I. publications in the *Journal*.

**General Co-operation.**—Invitations to join other Institutions in meetings of common interest, or to give an opinion on radio subjects to be published in another association's journal, are always referred to the Technical Committee. There has been some development of this principle of co-operation by the arrangements made in Local Sections for joint meetings with other bodies. Many members appreciate the arrangements made for advice of particular meetings arranged by other organizations.

During the year, extracts from the Institution's *Journals* were published in other proceedings and journals. Acknowledgment to the Institution has always been given and several books, some written by members of the Institution, have also

utilized material previously published in the *Journal*.

**1951 Convention.**—A discussion with other bodies has taken place in regard to the possibility of joint arrangements during the 1951 Convention. In addition, members of the Committee and the Secretary have visited organizations interested in discussing the contributions to the Convention as part of the general wish to provide some contribution to the 1951 Festival of Britain.

Council has accepted the principle that the Convention arrangements will be divided into six sessions. The Chairmen appointed will be assisted by the Technical Committee in making complete arrangements for their particular group of meetings. A great deal of co-operation has already been given and promised, and it is hoped to be able to publish complete arrangements for the Convention in the early autumn.

Mention has already been made of the decision of Council to stagger the Convention over the whole period of the Festival of Britain. This will be done by having a three- or four-week interval between each session, each of which will last three days. The venues for these sessions, together with the titles and authors of the individual contributions, will be published later.

The subjects so far selected for the Convention and the respective Chairmen are as follows:—

- (1) Electronic Instrumentation in Nucleonics—Chairman : Dr. Dennis Taylor.
- (2) Audio Engineering—Chairman : Mr. H. J. Leak.
- (3) Television—Chairman : The retiring President (Mr. L. H. Bedford).
- (4) Valve Technology and Manufacture—Chairman : Mr. J. W. Ridgeway.
- (5) Radio Communication and Broadcasting—Chairman : The President-elect (Mr. P. Adorian).
- (6) Navigational Aids—Chairman to be appointed.

Finally, the Committee expresses pleasure at the nomination of Mr. Paul Adorian to the office of President of the Institution. First appointed to the Technical Committee early in 1943, Mr. Adorian has since been a regular member of the Committee, continuing to attend meetings throughout his four years as a Vice-President.

## FINANCE COMMITTEE

The audited accounts for year ended March 31st, 1949, appear on pages 274-7. Following devaluation, there has been a steep rise in certain items. Administrative costs, other than expenditure on publications and printing, are, however, very much below the percentage of increase in income. Comparative figures for last year show that the outstanding feature of the year's accounts is the very considerable increase in the cost of publishing the *Journal*. The increased cost of paper and printing is so generally known as not to require explanation in this report.

Whilst it is right that a large portion of the funds of the Institution, apart from the maintenance of its permanent office, should be devoted to publications and the arrangement of meetings, these essential activities cannot be separated from the other work of the Institution. Indeed, in order to fulfil its objects, the Institution must finance a very wide range of activity, much of it involving forward expenditure.

The income account shows an increase from all sources and whilst the Finance Committee has endeavoured to keep expenditure below the income level, the very rapid increase in printing costs has off-set the efforts made. Moreover, it has been necessary to budget for the further increases which continue to be made in the cost of what might be described as raw material which it is necessary for the Institution to purchase.

During the past five years income has increased from £5,000 to nearly £12,000 and, over the same period, fixed assets have been increased by £2,500. Apart from management and running expenses, however, a considerable amount has been invested in essential equipment, which is shown in the Balance Sheet under Fixed Assets. This year, for example, the opportunity was taken to renew completely the automatic addressing and mailing machines.

Expenditure is, of course, reduced pro rata with the increase in membership and although this year has been a difficult one, the Committee is confident that with the maintenance of increased membership figures it should be possible to restrict expenditure to its present level, thus obtaining each year a surplus, however small, of income over expenditure.

Finally, the Committee reports some loss in advertising revenue which partly accounts for the steep rise in the cost of publications. The Institution does not, at present, employ any special means of securing the support of advertisers but such a course may be necessary although involving an increase in rates. Many publishers have found it necessary to announce such increases and this step would be justified by the fact that *Journal* rates per page per thousand of circulation have stood previously at only about one-half the national average for technical publications. Commercial appreciation of the advertising value of the *Journal* is growing, although members can assist by drawing the attention of their commercial departments to this medium.

**The Building Fund.**—In the last Annual Report it was stated that the Council had authorized an appeal for financial help to enable a fund to be collected for the purchase of permanent headquarters for the Institution, in the same way as funds have been raised by other Institutions for this purpose. As the income account shows, the amount donated is not large. Special thanks are due to those members who have subscribed, but it is necessary that there should be more liberal support in order that a wider appeal may be made for help outside the Institution. Such an appeal could not be launched until there is proof of the support which it is only right to expect from the members themselves.

Council is investigating the possibility of accepting gifts for this purpose under Deeds of Covenant and if this is possible, then it is hoped to implement the appeal in order to raise a minimum sum of £10,000 within the next seven years.

Meanwhile, the Committee recommended to the Council that the arrangements for continuing the lease of the existing building should be approved. Until it is possible to launch fully the building fund appeal it is not felt that the Committee should waste time on a preliminary study of a project which could impose too great a burden on the general funds of the Institution. The first step is to be sure of support from the membership.

A great deal of structural repair and maintenance work has been carried out at 9 Bedford Square as promised in the last Annual Report.

*(Continued on page 278)*

GENERAL ACCOUNT FOR THE YEAR ENDED 31st MARCH, 1950

<i>EXPENDITURE</i>				<i>INCOME</i>			
1949		£ s. d.	£ s. d.	1949		£ s. d.	£ s. d.
£	To Examination Expenses including			£			
	Printing of Papers, Examiners' and			7,579	By Subscriptions including Arrears .. .. .	7,727	15 5
	Invigilators' Fees and Incidental			63	„ Compounded Subscriptions—Life Members .. .. .	—	— —
468	Expenses .. .. .		543 7 8	84	„ Donations to Building Fund. .. .. .	139	17 11
	„ Printing and Publishing Journal, Re-			244	„ Proceeds of Baggaly Bequest .. .. .	20	0 0
	ports, Regulations and Year Book,			697	„ Examination and Exemption Fees .. .. .	919	11 5
914	less Advertising Receipts .. .. .		2145 12 1	336	„ Entrance and Transfer Fees .. .. .	333	13 6
4,790	„ Salaries and State Insurance .. .. .		5,071 2 0	1,198	„ Sale of Examination Papers, Reprints and Journal	1,894	16 4
453	„ Postage and Telephone .. .. .		465 8 10	12	„ Interest on Investments (Gross) .. .. .	12	0 0
	„ Institution Premises :—				„ Radio Trades Examination Board—Secretarial		
728	Rent, Rates and Insurance .. .. .	698 0 3		400	Charges and Expenses Incurred .. .. .	400	0 0
123	Lighting and Heating .. .. .	134 14 7		—	„ Excess of Expenditure over Income .. .. .	1,216	7 11
214	Office Expenses and Cleaning .. .. .	217 5 2					
—	Repairs .. .. .	569 11 7	1619 11 7				
385	„ Printing, Stationery and Certificates .. .. .		764 16 11				
599	„ Secretary's and Delegates' Expenses .. .. .		573 8 3				
807	„ Section Meeting Expenses .. .. .		783 1 5				
42	„ Audit and Accountancy Fees .. .. .		42 0 0				
97	„ Bank Charges and Cheque Books .. .. .		130 7 8				
150	„ Grants to Other Institutions .. .. .		121 15 0				
182	„ Sundry Expenses .. .. .		122 18 8				
49	„ Premiums and Awards .. .. .		37 0 9				
	„ Depreciation :—						
161	Office Furniture and Fittings .. .. .	192 1 0					
50	Library .. .. .	51 10 8	243 11 8				
401	„ Excess of Income over Expenditure .. .. .		— — —				
			£10,613				£12,664 2 6
							£10,613
							£12,664 2 6



**BALANCE SHEET AS AT 31st MARCH, 1950**

<i>RESERVES</i>				<i>FIXED ASSETS</i>											
£		£ s. d.	£ s. d.	£		£ s. d.	£ s. d.								
500	Library Reserve Account .. ..		500 0 0	1,452	Office Furniture and Fittings at Cost ..	2,663 5 2									
					Less Depreciation to date .. ..	927 5 2	1,736 0 0								
<i>CURRENT LIABILITIES</i>															
1,336	Sundry Creditors .. .. .	1,464 1 7		454	The Louis Sterling Library at Cost ..	762 2 10									
	Subscription and Examination Fees in				Less Depreciation to date .. ..	295 2 10	467 0 0								
874	Advance .. .. .	876 18 8		400	Investments at Cost—£400 3 per cent.										
2,695	Bank Overdraft .. .. .	4,114 14 7			Defence Bonds .. .. .		400 0 0								
		6,455 14 10		2,306			2,603 0 0								
				<i>CURRENT ASSETS</i>											
				1,843	Stock of Stationery, Journals and Examination Papers at Cost ..	1,950 5 8									
				1,003	Sundry Debtors, and payments in advance, including Subscriptions in arrear ..	926 9 9									
				8	Prize Fund* .. .. .										
				28	Cash in Hand .. .. .	29 3 6									
				31	Cash at Bank, No. 3 Account .. ..	43 16 8									
							2,949 15 7								
				<i>RESERVE ACCOUNT</i>											
					Balance as at 1.4.49 .. .. .	186 11 4									
				186	Add Excess of Expenditure over income for the year .. .. .	1,216 7 11									
							1,402 19 3								
<b>£5,405</b>				<b>£6,955 14 10</b>				<b>£5,405</b>				<b>£6,955 14 10</b>			

Signed { L. H. BEDFORD (President).  
 J. L. THOMPSON (Chairman of Council).  
 S. R. CHAPMAN (Hon. Treasurer).  
 G. D. CLIFFORD (General Secretary).

\*Note : The Prize Fund has been excluded from this Balance Sheet and a separate account, S. R. Walker Prize Fund, is attached.

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit In our opinion, proper books of account have been kept by the Institution so far as appears from our examination of those books.

We have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of account. In our opinion and to the best of our information and according to the explanations given to us the said accounts give the information required by the Companies Act, 1948, in the manner so required, and the Balance Sheet gives a true and fair view of the state of the Institution's affairs as at the 31st March, 1950, and the Income and Expenditure Account gives a true and fair view of the excess of expenditure over income for the year ended on that date.

10th July, 1950.

74 Victoria Street, Westminster, S.W.1.

GLADSTONE, TITLEY & CO.,

Chartered Accountants.

**THE PRESIDENT'S PRIZE FUND**  
**INCOME ACCOUNT FOR THE YEAR ENDED 31st MARCH, 1950**

£		£ s. d.	£		£ s. d.
2	To Awards .. .. .	8 7 0	8	By Interest Received (Gross) .. .. .	7 10 0
11	„ Balance being Surplus for Year carried to Reserve Account .. .. .	— — —	5	„ Income Tax Repayment 1946/7 and 1947/8 .. .. .	— — —
			—	„ Balance being Deficiency for year carried to Reserve Account .. .. .	17 0
<u>£13</u>		<u>£8 7 0</u>	<u>£13</u>		<u>£8 7 0</u>

**BALANCE SHEET AS AT 31st MARCH, 1950**

<i>LIABILITIES</i>				<i>FIXED ASSETS</i>			
		£ s. d.	£ s. d.			£ s. d.	£ s. d.
£	<i>Reserve Account :—</i>			£	<i>Investments at Cost :—</i>		
242	Balance as at 1st April, 1949 .. ..	255 14 11			£200 3 per cent. Savings Bonds .. ..	200 0 0	
3	Less Deficiency for Year .. ..	17 0		250	£50 3 per cent. Defence Bonds .. ..	50 0 0	
			254 17 11				250 0 0
	<i>Current Liabilities :—</i>				<i>Current Assets :—</i>		
2	Due to General Account .. ..		1 16 7	5	Due from Benevolent Fund .. ..	6 14 6	
				3	Income Tax Repayment Claim on Savings Bond Interest .. ..	— — —	
<u>£258</u>			<u>£256 14 6</u>				6 14 6
				<u>£258</u>			<u>£256 14 6</u>

**S. R. WALKER PRIZE FUND**  
**INCOME ACCOUNT FOR THE YEAR ENDED 31st MARCH, 1950**

	£ s. d.		£ s. d.
To Award .. .. .	3 15 0	By Cash Received .. .. .	115 15 0
To Balance being Surplus for Year carried to Reserve Account .. .. .	112 17 3	By Interest Received (Gross) .. .. .	17 3
	<u>£116 12 3</u>		<u>£116 12 3</u>

BALANCE SHEET AS AT 31st MARCH, 1950

<i>LIABILITIES</i>		<i>FIXED ASSETS</i>	
	£ s. d.		£ s. d.
<i>Reserve Account :—</i>		<i>Investment at Cost :—</i>	
Surplus for Year .. .. .	112 17 3	£100 2½ per cent. Defence Bonds .. .. .	100 0 0
Less Overdrawn Balance at 1.4.49 ..	7 14 2	Due from General Fund .. .. .	5 3 1
	105 3 1		
	£105 3 1		£105 3 1

**DR. NORMAN PARTRIDGE MEMORIAL FUND**  
INCOME ACCOUNT FOR THE YEAR ENDED 31st MARCH, 1950

£	£ s. d.	£	£ s. d.
- To Awards .. .. .	10 10 0	6 By Interest Received (Gross) .. .. .	6 0 0
To Balance being Surplus for the Year carried to		By Balance being Deficiency for the year carried	
6 Reserve Account .. .. .	- - -	to Reserve account .. .. .	4 10 0
	£10 10 0		£10 10 0
£6	£10 10 0	£6	£10 10 0

BALANCE SHEET AS AT 31st MARCH, 1950

<i>LIABILITIES</i>		<i>FIXED ASSETS</i>	
	£ s. d.		£ s. d.
<i>Reserve Account :—</i>		<i>Investments at Cost :—</i>	
219 Balance as at 1st April, 1949 .. .. .	219 6 5	200 £200 3 per cent. Defence Bonds .. .. .	200 0 0
Less Deficiency for Year .. .. .	4 10 0	<i>Current Assets :—</i>	
	214 16 5	12 Due from Benevolent Fund .. .. .	18 0 0
<i>Current Liabilities :—</i>		7 Cash at Bank .. .. .	7 6 5
- Due to General Account .. .. .	10 10 0		25 6 5
	£219		£225 6 5
£219	£225 6 5	£219	£225 6 5

We have audited the above written Balance Sheets dated 31st March, 1950, in respect of The President's Prize Fund, the S. R. Walker Prize Fund and the Dr. Norman Partridge Memorial Fund. We have received all the information and explanations we have required and in our opinion the Balance Sheets represent the true and accurate state of the Funds.

10th July, 1950.  
74 Victoria Street, London, S.W.1.

Signed { L. H. BEDFORD (*President*).  
J. L. THOMPSON (*Chairman of Council*).  
S. R. CHAPMAN (*Hon. Treasurer*).  
G. D. CLIFFORD (*General Secretary*).

GLADSTONE, TITLEY & CO.

(Continued from page 273)

The cost has been mainly met from general income, and as there is still a considerable amount of work to be done, further expenditure is necessary during the next twelve months. It will thus be obvious that calls have to be made on the present Building Fund to meet the needs of existing Headquarters. The main costs should, however, be cleared in 1950/51, thereby enabling the Committee to concentrate on exploring the possibility of acquiring, at the end of the present lease, better and permanent property.

**Other Special Funds.**—Statements of Accounts for the President's Prize and Dr. Norman Partridge Memorial Award Funds are appended together with a first statement on the S. R. Walker Prize Fund. The latter has been made possible by the generous donations of Mr. Samuel Robert Walker, who, since his election as a Member in 1939, has paid for the prize awarded annually to the candidate taking 2nd place in the Institution's Graduateship Examination. Mr. Walker's further contribution has, with his permission, enabled a Fund to be established to finance the award permanently.

The establishment of these special funds, first started in 1944, contributes a great deal towards furthering the work of the Institution and relieving strain on the General Fund. The difficulties of the earlier years prove that there is no reason to be unduly fearful because of present conditions. A continually increasing membership and hoped-for improvement in world affairs will ensure the prosperity of the Institution.

## GENERAL

Unfortunately, present world affairs may not justify the immediate celebration of the Silver Jubilee. Believing in the desirability of these functions, if only to give members a national opportunity of meeting, Council did make preparations for a banquet. It is hoped that more favourable opportunities will occur in the early part of next year when such a celebration might be held concurrently with the 1951 Convention.

In reviewing the progress made during the year the Council has endeavoured to pay tribute to the work done during the first 25 years of the Institution. Whilst that is a short time in the life of a corporate organization, much has been accomplished. The Council recognizes that the fruits of the work of those members who formed the nucleus of the Institution during its jubilee growth will, inevitably, be reaped by a new generation of members. Their inheritance and personal qualifications will ensure that the foundations laid will endure for ever.

**The Staff.**—Finally, the Council wishes to record its deep appreciation of the work of the Institution's permanent staff. During a critical period the staff have demonstrated the utmost loyalty and willing co-operation in maintaining the efficiency of administration. Council has been most impressed with this work and regrets that it is not possible to make any further report on the proposal to inaugurate a pension scheme. By modern standards such a reward for service is necessary and the Council are anxious to establish such a scheme as soon as circumstances permit.

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This report was agreed at the Council meeting held on July 27th, 1950, and will be submitted for approval of corporate members at the Annual General Meeting to be held on September 27th, 1950.



## BENEVOLENT FUND

NOTICE IS HEREBY GIVEN that in accordance with the Rules, the Annual General Meeting of subscribers to the Institution's Benevolent Fund will be held on WEDNESDAY, SEPTEMBER 27th, 1950, at 7 p.m., at the London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), London, W.C.1.

### AGENDA

- (1) To receive the Income and Expenditure Account and the Balance Sheet of the Benevolent Fund of the British Institution of Radio Engineers for the year ended March 31st, 1950.
- (2) To receive the Annual Report of the Trustees.
- (3) To elect the Trustees for the year 1950/51. The Trustees elected at the last Annual General Meeting were :—

Sir Louis Sterling, D.Lit. (Chairman)

Sir Ernest Fisk

Mr. Leslie McMichael

The President of the Institution

The Chairman of Council.

- (4) To elect Honorary Solicitors and Honorary Accountants to the Benevolent Fund.  
The Trustees recommend the appointment of Messrs. Braund & Hill, 6 Grays Inn Square, London, W.C.1, as Honorary Solicitors

and

Mr. R. H. Jenkins, F.C.A., 74 Victoria Street, London, S.W.1, as Honorary Accountant.

- (5) Any other business.

### Annual Report of the Trustees for the Period 1st April, 1949, to 31st March, 1950

For reasons of economy, a list of contributors to the Fund has not been published, but this practice will be resumed as soon as conditions permit. The Accounts appended show that donations by members continue to increase each year, thus permitting further investments without impairing maximum help to deserving cases. Obviously, the revenue derived from investments is of great help in adequately providing grants.

In the last ten years the assets of the Fund have increased by over £2,600, notwithstanding the grants made throughout those years. As reported last year, the Trustees have never had to refuse help to all the deserving cases which have been

considered since the inception of the Fund.

Increasing membership of the Institution emphasizes the need for greater support of this work ; unfortunately, contributions are only received from a small percentage of the total membership, and it is hoped that the remainder will endeavour to assist because donations are urgently required, no matter how small they may be.

**Subscribers.**—The average contribution per member subscriber was 16s. 3d. The only industrial subscriber was Electric & Musical Industries, Ltd., and there were three additional non-member subscribers.

**Local Sections.**—During the year, members of two of the Local Sections gave valuable help to the Trustees in the investigation of applications for assistance. The development of the Institution makes it desirable that there should be particular help from all Sections of the Institution and the Trustees hope that the Section Committees will consider ways of stimulating local interest in the Fund.

**Grants.**—Four new applications were dealt with, and in each case the Trustees made a grant. Three of these were widows of former members, their main concern being the care and education of their children. Subscribers, and indeed the entire membership, know that the best way in which the Fund can be of help in such cases is through the good offices of Reed's School.

**Reed's School** —During the twelve months ended March 31st, 1950, three children of former members have been placed in Reed's School, and so far as required by the School, the Trustees have, on behalf of the Benevolent Fund, accepted responsibility.

The Trustees do emphasize, however, that whilst building up a Fund, and at the same time providing necessary assistance, it has not been possible to subscribe a very large amount to Reed's School. The fact that the Institution's various applications to the School have met with such favourable response is very largely due to the personal association and direct donations made by some of the members of the Institution. Whilst the personal work of these few members has benefited the dependants of late members, the Trustees are confident that with the evidence now provided of the School's kindly disposition towards the Institution, all members will agree with the Trustees' decision to contribute toward the cost of educating these children.

In most cases it is, of course, impossible for the mother to contribute anything to the School. Moreover, Reed's School has not charged any fees, being entirely dependent on subscribers.

Whilst under the provisions of the 1944 Education Act the Schools hope to secure some assistance through local authorities, it is quite obvious that for this type of boarding school education for fatherless or orphan children, the School will have to depend upon the contributions received from such organizations as the Institution.

The return received in free education and board for our members' children will more than justify these contributions.

Example has been given of the way in which assistance has been given during the past year to the dependants of three members. As explained, that timely help has been rendered largely with the assistance of individual members, but also by grants made through the Benevolent Fund. Other typical examples of cases brought before the Trustees were dealt with in the last Annual Report. A further case is that of a member who was taken ill at the same time as his two children were undergoing surgical operations. This resulted in financial hardship which the Trustees were able to relieve by a grant.

Finally, the Trustees, through the Honorary Secretary, welcome the help given by members in drawing attention to cases which justify assistance through the Fund. Diffidence in approaching the Trustees is often shown by those most deserving of help.

**Refund of Income Tax.**—The Fund is able, under the provision of the Finance Acts, to recover income tax on annual subscriptions, provided the subscribing member signs a Deed of Covenant to give a fixed amount per annum for a minimum period of seven years, or until the death of the subscriber, whichever is the shorter period.

Many members now include a contribution when remitting their annual subscriptions. The completion of a Deed of Covenant would enable the Institution to recover a considerable amount from the Commissioners of Inland Revenue. The Honorary Secretary of the Fund will be pleased to supply members and present subscribers with the necessary form and particulars.

**BENEVOLENT FUND**  
**INCOME ACCOUNT FOR THE YEAR ENDED 31st MARCH, 1950**

	£	£ s. d.		£	£ s. d.
65 To Grants .. .. .		70 10 0	503 By Subscriptions and Donations .. .. .		523 0 6
„ Balance, being Surplus for Year carried to Reserve Account .. .. .		508 17 6	41 „ Interest Received (Gross) .. .. .		56 7 0
	£544	£579 7 6		£544	£579 7 6

**BALANCE SHEET AS AT 31st MARCH, 1950**

<i>LIABILITIES</i>				<i>FIXED ASSETS</i>			
		£ s. d.	£ s. d.			£ s. d.	£ s. d.
£	<i>Reserve Account</i> :—			£	<i>Investments at Cost</i> :—		
2,408	Balance as at 1st April, 1949 .. .. .	2,408 7 6			£1,600 2½ per cent. Defence Bonds ..	1,600 0 0	
	<i>Add Surplus for Year</i> .. .. .	508 17 6			£900 3 per cent. Defence Bonds ..	900 0 0	
			2,917 5 0		£100 3 per cent. Savings Bonds ..	100 0 0	
	<i>Current Liabilities</i> :—				£100 3½ per cent. War Loan ..	104 0 0	
5	Due to President's Prize Fund ..	6 14 6		2,304		2,704 0 0	
12	Due to Dr. Norman Partridge Memorial Fund .. .. .	18 0 0	24 14 6		<i>Current Assets</i> :—		
				76	Due from General Account .. .. .	211 5 8	
				45	Cash at Bank .. .. .	26 13 10	
						237 19 6	
				£2,425		£2,941 19 6	£2,941 19 6

I have audited the above written Balance Sheet dated 31st March, 1950, in respect of the Benevolent Fund. I have received all the information and explanations I have required and in my opinion the Balance Sheet represents the true and accurate state of the Benevolent Fund.

10th July, 1950.  
 74 Victoria Street, London, S.W.1.

Signed { L. H. BEDFORD } Trustees  
 { J. L. THOMPSON }  
 G. D. CLIFFORD (Hon. Secretary)

R. H. JENKINS, F.C.A.,  
 Honorary Auditor.

## NOTICES

### South Wales Television Transmitter

Replying to a question in the House of Commons on July 12th, the Postmaster-General stated that the B.B.C. were negotiating for the purchase of a site for the South Wales television station at St. Nicholas, near Cardiff. Construction would begin as soon as the plans were approved and the Corporation expected that this would be before the end of this year. The transmitters had already been ordered.

In reply to further questions, Mr. Ness Edwards said that the link from London to the transmitter would be by cable at first. The proposed centimetric radio link could not be provided until a much later date and coaxial cables already in existence along most of the route would to a large extent be available for television.

### Radio Component Specifications

Five further specifications for components have been published by the Radio Industry Council, making six so far in the series which will eventually cover all components in general use in the radio and electronic industries. The first, issued early this year, was RIC/122—Resistors Rotary Variable, Composition Track (With or Without Switches). The series was described fully in the May issue of the Journal.

The new specifications are :—

- No. RIC/111—Resistors, Fixed, Wire-wound, Non-insulated
- No. RIC/112—Resistors, Fixed, Composition, Grade I
- No. RIC/113—Resistors, Fixed, Composition, Grade II
- No. RIC/131—Capacitors, Fixed, Paper Dielectric, Tubular Foil
- No. RIC/132—Capacitors, Fixed, Mica Dielectric, Stacked Foil

At present the specifications are meant for use within the industry, but it is intended to submit them eventually to the British Standards Institution, by which time, it is hoped, it may be possible to co-ordinate the industrial and Service needs in one comprehensive national standard.

Copies of the specifications are obtainable from the Radio Industry Council, 59 Russell Square, London, W.C.1, price 4s. each, post free. This includes the cost of schedules of types, values and sizes which are to be published later.

### Conference on Production

On November 15th and 16th the Utilization Section of the Institution of Electrical Engineers are holding a conference on "Electricity as an Aid to Productivity" in order to make available to industry the most up-to-date information concerning the contribution that factory electrification can make to the country's efforts towards increased production.

The conference is mainly intended for those executives in both large and small factories who are responsible for production, and will consist of a series of lectures each of which will be followed by a general discussion. It has been planned, as far as possible, from the point of view of the user, and the lectures will therefore cover, in general terms, what electricity can do to increase production rather than give full technical details of the apparatus with which these improvements can be achieved. It is thus hoped to stimulate thought on the part of the audience so that, after the conference is over, they may act on what they have heard, obtaining the further information they will require from established sources. The subject matter of the lectures will come under the following broad headings : (a) Motive power in the factory, (b) Industrial heating processes, (c) Welding applications, (d) The handling and inspection of materials, and (e) Lighting, heating, ventilation, etc.

The proceedings of the conference will be published and issued to all interested parties so as to reach as wide an audience as possible.

The aim will be to focus attention on the effect that electricity can have on the economics of production, embracing both quantity and quality, and to show how electricity can help to produce an ever increasing output.

### British Standards

The British Standards Institution has recently issued Supplement No. 4 (1950) to the British Standard 204 : 1943. This publication, "Glossary of terms used in Radar," has been prepared by the Electrical Industry Standards Committee upon which the Institution is represented.

Copies are obtainable from the Sales Department of the British Standards Institution, 24/28 Victoria Street, London, S.W.1, price 2s. post free.

# ON THE OPERATION OF THE TRAVELLING WAVE TUBE AT LOW LEVEL\*

by

R. Kompfner, Dipl.Ing.†

*A paper read before the London Section on March 3rd, 1950*

## SUMMARY

The small-signal theory of the travelling wave tube is developed on the assumption of finite distributed attenuation in the helix and beam voltages other than the "synchronous" voltage. On restricting the gain parameter  $\alpha$  to values less than 2, it appears that a simplified analysis gives results in error, by not more than about 6 per cent. The voltage gain is then derived for the particular case of the first "zero-gain" point, when the travelling wave tube presents an infinite attenuation to a signal at the input. It is shown that, under these conditions, a measurement of beam current enables an estimate of the effective impedance of the helix to be made, a parameter that is of considerable importance in designing travelling wave tubes. Theoretical and experimental results are presented.

### 1.0. Introduction

The travelling wave tube (abbreviated T.W.T.) is a microwave amplifying device, known to give positive gain at wavelengths between 1.5 m and 6 mm.<sup>1</sup> In its most common form it consists of a helix of metallic wire which propagates the signal in the form of a retarded travelling wave, and an electron beam shot along the axis of the helix with about the same speed as the wave. Interaction between the wave and the electrons take place which results in a progressive increase of the energy in the wave, usually several hundred-fold. This energy transfer can take place over a band of frequencies often only limited by the bandwidth of the matching arrangements used to transfer the signal to and from the helix. Overall bandwidths (to half-power points) of about one third of the centre frequency have been realised.

Since some reflection of signal energy takes place at both ends of the helix which might cause the T.W.T. to oscillate, various devices have been used to reduce the amplitude of the wave deflected from the output end. The simplest of these is attenuation distributed along the helix in a uniform manner, achieved either by making the wire of a high-resistance metal or by making use of the R.F. loss in the rods or tube which support the helix. It appears that such attenuation does not seriously diminish the rate of build-up of the wave.

A theory of operation of the T.W.T. has been worked out<sup>2</sup> making a number of simplifying assumptions, based on the view that it is permissible to calculate (a) the effect of the wave on the electron beam (b) the wave induced by the resulting beam modulation (c) the modulation produced by the induced wave, and so on, *ad infinitum*; the sum of all these waves constitutes the amplified signal wave. For large amplification, the power gain can be written

$$G = e^{\sqrt{3}z} \dots\dots\dots (1)$$

where  $z = \frac{2\pi l}{\lambda} \left( \frac{\alpha^2 Z_0 I_0}{4V_0} \right)^{\frac{1}{2}}$

and where

- $l$  is the active length of the helix,
- $\lambda$  the wavelength in the helix,
- $\alpha^2 Z_0$  the effective impedance of the helix,
- $I_0$  the beam current,
- $V_0$  the beam voltage.

Two main assumptions have been made in deriving equation (1); namely that wave and electron velocities are equal, and that there is no attenuation along the helix. If an attempt is made to solve the theory of the T.W.T. rigorously, expressions of such prohibitive complexity are soon obtained, that solution in closed form appears impossible.

Other workers in this field however<sup>3, 4, 5, 6</sup> have tackled the theory by methods which give comparatively simple expressions even when wave and electron velocities are not equal and

\* Manuscript received March 3rd, 1950.

UDC No. 621.385.029.63/64.

† Clarendon Laboratory, Oxford.



when finite attenuation is taken into account. However, these expressions seem only to be valid on the assumption of large gain.

It is the purpose of this paper to describe the behaviour of the T.W.T. under conditions of low gain, where a tube of normal construction does not amplify at all. The practical interest of running a tube under these conditions lies mainly in the fact that it is then possible to compare theory and experiment with a high degree of confidence and all relevant factors can be taken into account.

It will be shown that it is possible to extend the theory<sup>2</sup> to include the effect of a beam voltage other than the synchronous one, and the effect of distributed attenuation, when one is content to stop the series of waves and beam modulations at the first induced wave. That is to say, it is assumed that the total wave in the helix is made up almost entirely of the original signal wave, and the wave induced by the beam modulation due to the original wave. This is intuitively true for very small beam currents, or for very short helices, and it will be shown that it is very nearly true under circumstances where the induced wave is of an amplitude comparable with the original wave.

## 2.0. Experimental Results

The experiment consists in observing the gain of the tube as a function of the beam voltage for various fixed values of beam current.

In practice, this experiment is performed with the help of a microwave signal generator that is periodically switched on and off, usually at the rate of about 1,000 c/s.\* The signal is injected into the T.W.T. ; it then travels along the helix, interacting with the electron beam all the way. The resulting signal emerging from the output end of the T.W.T., after further amplification and linear rectification, is displayed on a cathode ray tube as the Y-deflection. The X-deflection is at 50 c/s, say.

If the beam voltage of the T.W.T. is also varied at 50 c/s we shall then have on the C.R.O. a representation of the gain of the T.W.T. as a function of beam voltage. This mode of representation is very useful and is

\* This is to enable the use of A.C. amplification at later stages of the experimental gear without losing the D.C. component of the signal.

quite common in testing T.W.T.'s in normal operation, as the beam voltage for maximum gain under various conditions, is obtainable at a glance. This method can also be used, for instance, to detect the presence of oscillations.

A number of typical C.R.O. traces are given in Fig. 1. They were obtained with a T.W.T. of conventional construction, the beam current of which was increased from zero upwards in steps as follows :

- (a) 0.5  $\mu$ A.
- (b) 10.0  $\mu$ A.
- (c) 14.0  $\mu$ A.
- (d) 30.0  $\mu$ A.
- (e) 50.0  $\mu$ A.
- (f) 80  $\mu$ A.
- (g) 150  $\mu$ A.
- (h) 200  $\mu$ A.

It should be noted that the amplitude of the un-amplified signal in the first picture—which is hardly affected by the beam voltage—does not represent unity gain. In fact, this particular tube had a distributed loss of some tens of decibels, and it is only at the higher beam currents—over 50  $\mu$ A in fact—that the tube gives real positive gain.

The third picture, (c) exhibits a phenomenon which can be described as zero-gain, or infinite attenuation.† Careful measurement, at this particular value of beam current and voltage, reveals that the amount of signal then emerging from the tube is, in fact, less than the amount of power unavoidably leaking out from the signal generator and forming a general background, and is therefore difficult to measure.

All that can be said with certainty is that the power then emerging from the T.W.T. is reduced from the value that would be measured in the absence of an electron beam, by about 80 decibels.

The values of beam current and beam voltage at which the first zero-gain dip occurs can be measured with considerable accuracy and it seems natural to find out whether any significant deductions can be made from these measurements. The most obvious explanation of the zero-gain dip is that it is due to interference between the original and the induced wave. That is to say, at the output of the T.W.T. the

† Curves of similar character are given in Rydbeck's paper<sup>4</sup>. The occurrence of zero-gain point is not discussed there however.

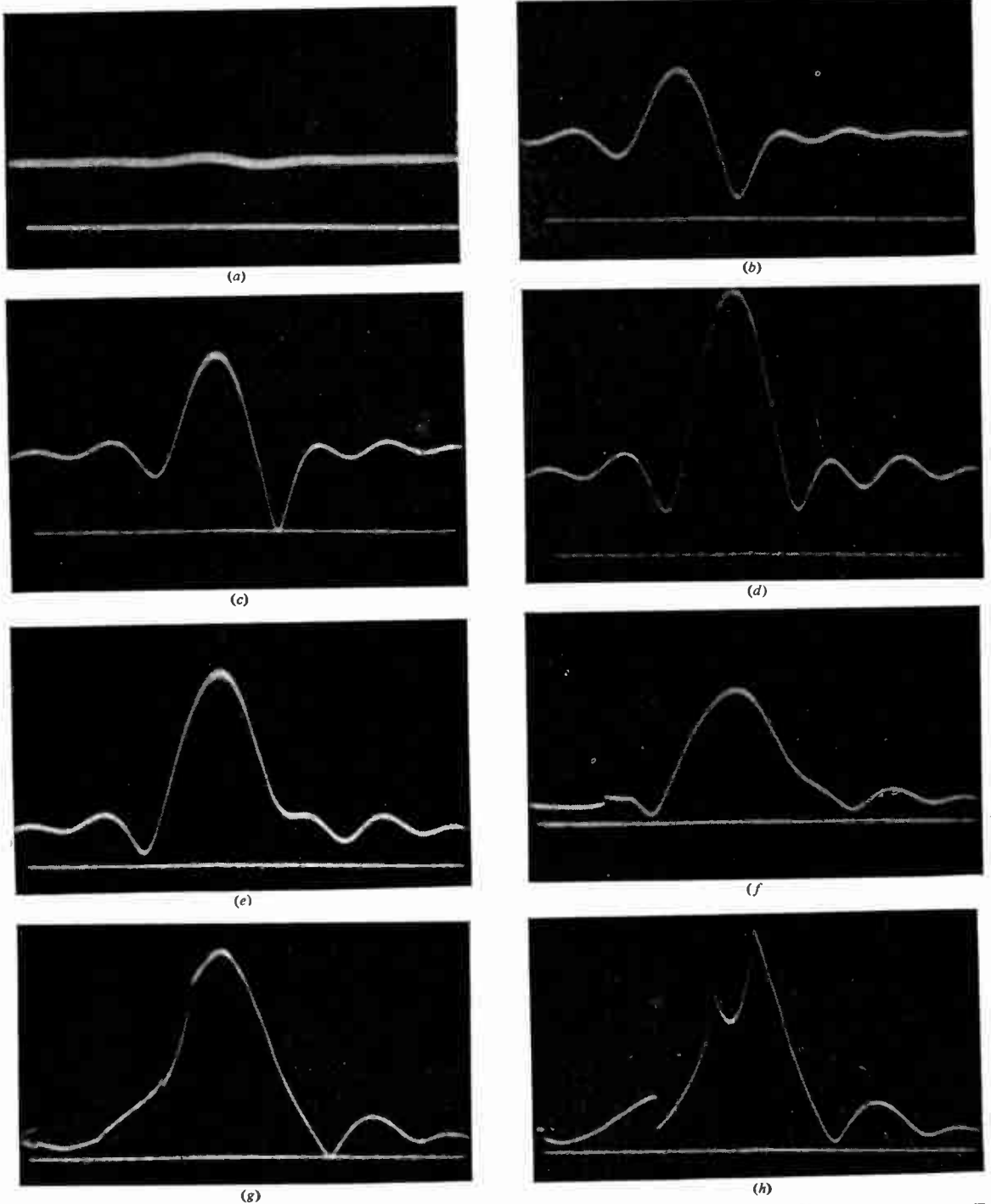


Fig. 1.— Cathode ray tube traces of gain versus beam voltage at various values of beam current obtained with a typical T.W.T.

amplitudes of the two waves are equal while their phases differ by 180 deg. Hence one would expect that some rather simple numerical relationships will then emerge. However, before going on to the extension of the theory necessary to establish the correspondence between experiment and theory, it may be opportune to conclude the comments on the oscillographs of Fig. 1.

(a) (b) and (c) can readily be envisaged as the result of the interference of a primary wave with a secondary wave of progressively increasing amplitude. (d) shows for the first time a marked increase or peak of gain near the synchronous beam voltage, typical of normal T.W.T. operation. "Wiggles" on either side of the peak are very noticeable. It should be noted that the scale of the representation has been reduced, in going from (d) to (e) in order to keep the peak of the curve within the limits of the C.R.O. screen, without, however, changing the beam voltage excursions. A further reduction had to be made for (f) which shows a very typical gain/voltage curve. The slight break at the high-voltage end of the trace indicates the presence of oscillations at that voltage (occurring at a frequency to which the experimental arrangement does not respond). In (g) the oscillation region has shifted nearer to the synchronous voltage, and in (h) it coincides with it. In practice, the tube would be run with a beam current of about 150  $\mu$ A as in (g), since the gain seems to have reached a maximum there and operation under conditions depicted in (h) would be rather unstable.

Zero-gain dips can be observed at various times as the beam current is increased; for instance, at the low-voltage side of (g). Such a dip is undoubtedly caused by the interference of a number of waves, but is of no further interest to us here.

### 3.0. Theoretical Analysis

The theory to be applied here is an extension of the one given in the "Wireless Engineer" (September 1947) paper.\*<sup>7</sup> The same assumptions are made here as there, except attenuation is no longer assumed to be zero. Thus it will be

\* Equations from that paper are distinguished by square brackets and are listed in the Appendix.

assumed that a signal voltage in the absence of the electron beam depends on distance  $x$  as follows:—

$$e^{-\gamma x}$$

that is to say the original signal voltage [2] is replaced by

$$V_1 = V e^{-\gamma x} \cos \left( \omega t - \frac{2\pi x}{\lambda} \right) \dots\dots(1)$$

Introducing the dimension—less factor  $\alpha$ —which indicates by how much weaker the axial field is at the position of the thin electron beam, than the axial field very close to the helix; and making the assumption that

$$\frac{\lambda}{2\pi} \cdot \gamma \ll 1 \dots\dots\dots(2)$$

we can write for the axial field at the position of the electron beam

$$\frac{\partial V_1}{\partial x} = V e^{-\gamma x} \frac{2\pi\alpha}{\lambda} \sin \left( \omega t - \frac{2\pi x}{\lambda} \right) \dots(3)$$

This field then "bunches" the electron beam, and the resulting amplitude modulation in the beam induces a secondary voltage wave in the helix, which has been derived in the above mentioned paper (equation [57]) on the assumption of no attenuation. However, there is no restriction on the beam voltage.

To derive an exact expression, equivalent to equation [57] but including attenuation, would be a very cumbersome procedure and is not attempted here. Instead, the assumption is made that the influence of attenuation and of the beam voltage can be derived independently, but combine them as factors finally in one expression. For a tube of only a few wavelengths long this would be a rather doubtful expedient; however, in practice tubes are many wavelengths long—30 or more—and the error thus committed must be very small indeed.

Proceeding in this way we have derived an expression for the secondary voltage;

$$V_2 = V z^3 e^{-\gamma x} f(\gamma x) \sin \left( \omega t - \frac{2\pi x}{\lambda} \right) \quad (4)$$

where  $z^3 = \left( \frac{2\pi x}{\lambda} \right)^3 \left( \frac{\alpha^2 Z_0 I_0}{4V_0} \right) \dots\dots\dots(5)$

and where

$$f(\gamma x) = \frac{\gamma x(1 + e^{\gamma x}) + 2(1 - e^{\gamma x})}{(\gamma x)^3} \dots\dots(6)$$

$f(\gamma x)$  has been plotted in Fig. 2.

Combining (4) and [57] we can write

$$V_2 = V e^{-\gamma x} z^3 \frac{\lambda^2}{\Lambda^2} f(\theta) \cdot f(\gamma x)$$

$$\sin \left[ \omega t - \frac{2\pi x}{\lambda} - \frac{\theta}{2} \right] \dots\dots(7)$$

where

$$\Lambda = \frac{v}{u} \cdot \lambda \text{ the "wavelength" in the beam,}$$

$$f(\theta) = \frac{12 \left( \frac{\sin \theta/2}{\theta/2} - \cos \theta/2 \right)}{\theta^2} \dots\dots(8)$$

$$\text{and } \theta = \frac{2\pi x}{\lambda} \left( \frac{u}{v} - 1 \right) \dots\dots(9)$$

(the phase shift in radians between an electron and the original wave).

$u$  is the velocity of the wave and  $v$  the electron velocity (given by  $v = (2e/m V_0)^{1/2}$ )

$f(\theta)$  has been plotted in Fig. 1 of the *Wireless Engineer* paper.<sup>7</sup> The total voltage at any point is the sum of the initial, the secondary, the tertiary, etc., voltages, and has been derived in the above mentioned paper on the assumptions of no attenuation, and of  $u = v$ . With attenuation, it will be observed that even the secondary voltage (equation (7)) is a rather complicated expression, and higher order voltages are of a forbidding complexity; the complete infinite series of these voltages has not been derived up to this date. However, it will be shown later that, unless accuracy higher than a few per cent. is required, it is sufficient to consider only the initial and the secondary voltage when calculating the total voltage.

We have thus

$$V_1 + V_2 = V e^{-\gamma x} \left[ \cos \left( \omega t - \frac{2\pi x}{\lambda} \right) + C \sin \left( \omega t - \frac{2\pi x}{\lambda} - \frac{\theta}{2} \right) \right] \dots\dots(10)$$

where

$$C = z^3 \frac{\lambda^2}{\Lambda^2} f(\theta) f(\gamma x) \dots\dots(11)$$

For  $|V_1 + V_2|$  to be zero, the following two conditions must be fulfilled simultaneously:

$$C = 1 \dots\dots(12)$$

$$\text{and } \frac{\theta}{2} = \frac{\pi}{2} \dots\dots(13)$$

This is then the theoretical description of the zero gain dip. From condition (13) it follows at once that at the dip\*

$$\theta^1 = \pi = \frac{2\pi x^1}{\lambda} \left( \frac{u}{v^1} - 1 \right) \dots\dots(14)$$

giving

$$\frac{u}{v^1} = 1 - \frac{\lambda}{2x^1} \dots\dots(15)$$

The beam voltage  $V_0^1$  for  $|V_1 + V_2| = 0$ , that is, for the zero point, is therefore

$$V_0^1 = \frac{V_0}{\left( 1 + \frac{\lambda}{2x^1} \right)^2} \dots\dots(16)$$

If we know  $V_0$ , the beam voltage giving the electrons a velocity equal to  $u$  with sufficient accuracy, the above expression gives us a means of determining  $x^1$ , the effective length of the travelling wave tube, which need not be identical with the physical length of the helix.

From the other condition, namely  $C = 1$ , using

$$\frac{\lambda^2}{\Lambda^2} = \left( \frac{u}{v^1} \right)^2 = \left( 1 + \frac{\lambda}{2x^1} \right)^2 = \frac{V_0}{V_0^1}$$

$$\text{and } f(\theta^1) = f(\pi) = \frac{24}{\pi^3}$$

we have

$$z^3 = \frac{\Lambda^2}{\lambda^2} \cdot \frac{1}{f(\theta^1) \cdot f(\gamma x^1)} = \frac{\pi^3 V^1}{24 V_0 f(\gamma x^1)} \dots\dots(17)$$

From the curve plotted on Fig. 2 it will be observed that  $f(\gamma x)$  is never smaller than  $\frac{1}{2}$ ; further  $V_0/V_0^1$  is very close to unity. Hence  $z$  can be taken to be smaller than  $\pi/2^{\frac{3}{2}} = 1.97$ . From [61] the ratio of the absolute magnitudes of  $V_2$  and  $V_3$  is then given by

\* All quantities relating to the zero-gain point are distinguished by primes.

$$\frac{6!}{z^3} = \frac{z^3}{120} = 0.064 \dots\dots\dots(18)$$

Hence the tertiary voltage, and all the higher order voltages can be neglected in our analysis so long as an accuracy of no higher than a few percent is required.

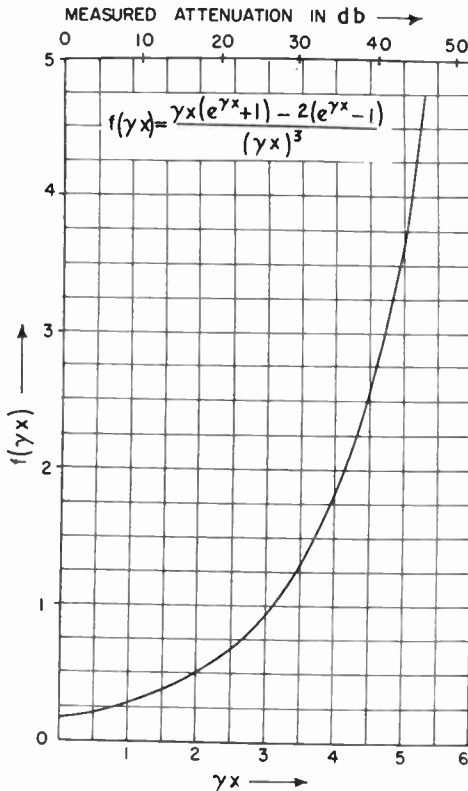


Fig. 2.—Attenuation formation  $f(\gamma x)$ .

Substituting for  $z^3$  we obtain  $\alpha^2 Z_0$ , the important impedance parameter of the tube :

$$\alpha^2 Z_0 = \frac{V_0^1 \lambda^3}{48 f(\gamma x) I_0 x^3} \dots\dots\dots(19)$$

All the values of the right hand side of equation (19) are known either directly or indirectly and thus we can calculate the impedance parameter  $\alpha^2 Z_0$  from the measurements of a single experiment. This is the main justification of the whole procedure.

Equation (10) can be transformed into

$$V_1 + V_2 = V e^{-\gamma x} \left( C^2 - 2C \sin \frac{\theta}{2} + 1 \right)^{\frac{1}{2}} \sin \left( \omega t - \frac{2\pi x}{\lambda} + \psi \right) \dots\dots(10a)$$

where the expression under the square root represents the amplitude of the total wave at  $x$  when the voltage is varied. The amplitude of (10a) has been plotted on the assumption of  $C = 1$  as function of  $\theta$ , (i.e. including the zero-gain point) in Fig. 3. When the number of wavelengths in the tube is large,  $\theta$  will be proportional to the fractional voltage deviation from the synchronous voltage and can be directly compared with the experimental cathode-ray tube trace of Fig. 1(c). It will be noted that the agreement is sufficiently good to give one confidence in the validity of the theory outlined above.

With some tubes, traces are obtained that deviate considerably from the theoretical pattern. It is believed that this is due to a helix of non-uniform pitch, or to bad focusing of the electron beam resulting in non-uniform interaction between beam and wave along the length of the tube.

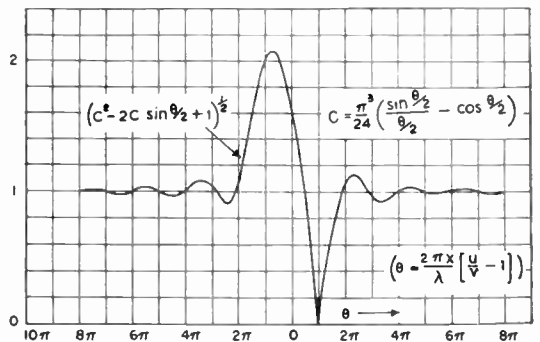


Fig. 3.—Amplitude of equation (10a). Compare with Fig. 1(c).

4.0. Numerical Example

For the sake of illustration, let us consider a practical example. The following measurements are available :

From the pitch of the helix and the actual length of the helix we have

$$\frac{x^1}{\lambda} = 30$$



From a measurement of the attenuation of the helix (without the beam), say 17 db, and using the graph on Fig. 2

$$\text{we have } \gamma x^1 \simeq 2$$

$$\text{and } f(\gamma x) = 0.5$$

Further, at the zero-gain dip, we measure

$$V_o^1 = 1,600 \text{ volts}$$

$$I_o^1 = 10^{-5} \text{ ampere}$$

Inserting these values into (19) we have

$$\alpha^2 Z_o = \frac{1600}{48 \times 0.5 \times 10^{-5} \times 30^3} \simeq 250 \text{ ohm}$$

This value for  $\alpha^2 Z_o$  is, of course, an average value taken over the cross section of the beam, and it will be found that it is rather sensitive to changes in the position or distribution of the beam. However, if the position and distribution of the electron beam does not vary materially when the current is increased up to the value at which it is intended to operate the tube, it should be possible to compare the performance of the tube with the theory throughout the range of beam current which can be used before oscillations set in.

One can also obtain a value of  $\alpha^2 Z_o$  from a series of measurements of overall gain versus beam current, based on the theories<sup>3,4,5,6</sup>. But it has been observed that such measurements do not give reliable and consistent results; this may be due to the fact that at relatively low currents the approximate theories do not apply anyway, and at high currents space-charge and other effects intervene.

It is therefore believed that the method of calculating  $\alpha^2 Z_o$  outlined above may yet be of some value to workers in the field.

**5.0. Acknowledgements**

The author is a member of the Royal Naval Scientific Service, working at the Clarendon Laboratory, Oxford. Permission to publish this paper is gratefully acknowledged.

The writer wishes to thank Mr. D. Walsh for help with the experiments and Mr. F. N. H. Robinson for the loan of tubes.

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**7.0. Appendix**

The following equations referred to in the text appeared in the paper "The Travelling Wave Tube," by R. Kompfner published on page 255 of the *Wireless Engineer*, September 1947.

$$V(xt) = V \frac{\sin \left\{ \omega t - \frac{2\pi x}{\lambda} \right\}}{\cos \left\{ \omega t - \frac{2\pi x}{\lambda} \right\}} \text{ volts} \dots\dots\dots [2]$$

$$V_2 = + V \frac{2\pi^3 \alpha^2 Z_o I_o}{V_o} \frac{x^3}{\lambda \Lambda^2} \left[ \frac{2 \sin \theta/2}{\theta/2} - 2 \cos \theta/2 \right] \theta^{-2} \sin \left[ \omega t - \frac{2\pi z}{\lambda} \left( \frac{u}{v} + 1 \right) \right] \dots\dots [57]$$

$$V_T = V \left[ 1 - (-j) \frac{z^3}{3!} + (-j)^2 \frac{z^6}{6!} - (-j)^3 \frac{z^9}{9!} + \dots\dots \right] \dots\dots\dots [61]$$

# EDUCATION AND TRAINING IN THE RADIO INDUSTRY

*A Survey prepared by the Education and Examinations Committee.*

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### 1.0. Introduction

The rapid developments in the application of radio and electronics in industry, in the Armed Forces and in all Government Departments have demanded a vast number of men and women with specialized knowledge and skill to man the organizations which have grown up and which, collectively, have now reached the full stature of a major industry. It is no longer possible for this industry to depend upon personnel recruited from other industries or upon those who had received only casual training. The universities, technical colleges and the industry itself, have seen the necessity for providing academic, technological and practical training which is in demand to-day.

### 2.0. Scope of Paper

This article attempts to show in brief the steps which have been taken to meet this demand. It is not practicable to cover here the typical training schedules of all grades of workers, nor does space permit of more than a brief resumé of the progress made in recent years. The paper supplements the Postwar Development Report in Radio Engineering (Part II, Education and Training), which was published in the *Journal* in October 1944.

### 3.0. Grades of Training

It is fully realized in the radio industry that if it is to compete successfully in the world's markets under the present-day conditions, it must be supplied with academically and technically trained staff in adequate numbers. Facilities for both types of training have already been much expanded to this end. Also, the whole pattern of the system for general education has been completely remodelled in accordance with the Education Act of 1944. The employment of university graduates in industry has, as the result of the Barlow Committee of 1946, been increased to the order of 60 per cent. above the pre-war figures. The increase in the number of engineering graduates also calls for an increased provision of facilities for works training. The technician class has not been forgotten, as it outnumbers the academic and professional grades by about ten to one. The technician is in many ways the backbone of the industry and it is not anticipated that the need for technicians will diminish. One of the chief problems in the future of the radio industry will be to see that technicians are recruited from those who have reached an acceptable standard of education and not from rejects of the new educational scheme.

#### 3.1. *Educational and Technical Courses*

##### 3.1.1. University Courses

Three- and four-year engineering courses are held at the universities which terminate in the final B.Sc. examination. Many of these courses lead to entire or partial exemption from the professional examinations.

### 3.1.2. Technical College Courses

Technical colleges throughout the country hold full-time courses of usually three years' duration which terminate in the Graduateship Examination of the Institution of Electrical Engineers, the Institution of Mechanical Engineers and the British Institution of Radio Engineers. They also cover the three years' external B.Sc. degree course, and three years' course for the Full Technological Certificate of the City and Guilds of London Institute. In addition, sandwich courses (viz., alternate works and college training), are held in engineering subjects, the periods of which may vary from one to four years.

### 3.1.3. Part-time Courses

Part-time day and night evening classes are held by technical colleges throughout the country, which cover the B.Sc. external degree, Graduateship Examination for the Institutions of Electrical Engineers and Mechanical Engineers, the British Institution of Radio Engineers and the Royal Aeronautical Society. They also cover City and Guilds' Certificates in Radio and allied subjects and the Ordinary and Higher National Certificates in Chemistry, Physics and Electrical Engineering. The technician class is catered for by the examinations of the Radio Trades Examination Board in Radio and Television, and the Postmaster-General's Certificate in Wireless Telegraphy.

### 3.1.4. Courses in Industry—Pre-entry Courses

Students undertaking these courses do a year at an industrial radio firm before taking the three years' engineering course at the university.

### 3.1.5. Assisted Courses

Nearly all the large firms in the radio industry give financial assistance to selected employees showing exceptional merit and high potentiality to attend courses of study by paying examination and course fees and out-of-pocket expenses. Leave of absence for examination preparation is also granted to employees taking university courses, and who are eligible for final year examinations.

## 3.2. Works Training Courses with Schedules

### 3.2.1. Post Graduate Industrial Courses

Students who have passed university courses undertake one to three years at radio firms.

These students are carefully selected on entry and are usually recruited by industry through the medium of University Appointments Boards.

Age on admission is usually between 20 to 25 years, but due to compulsory military service, some flexibility in regard to age is necessary, and relaxation is made in special cases.

Minimum starting basic salary is usually dependent on the class of degree obtained in the university course and is of the order of £325 per annum. Students are usually graded for different types of training, e.g., Research, Development or Production.

The scope of the course naturally varies with the type of firm, but the average ratio "post graduate" covers the following subjects :—

#### (a) *Basic Mechanical Engineering*

- (i) Training in the use of hand tools, sheet metal work and machine tools.
- (ii) Soldering, brazing, welding (including spot, arc and oxy-acetylene).
- (iii) Chassis wiring, sub-assemblies and coil winding.

#### (b) *Design*

Machine drawing and fundamentals of design.

#### (c) *Time and Motion Study*

- (i) Time and Motion Studies.
- (ii) Methods and Layouts.
- (iii) Rates and Ratefixing.

#### (d) *Production Planning*

- (i) Production Control.
- (ii) Quality Control.
- (iii) Estimating and Costing.

Students usually act as supervisors for a time in the various departments. Students are also allowed one day per week for education classes and technological courses in special processes and techniques.

### 3.2.2. Industrial Apprenticeship Schemes

These are divided into two main categories :—

- (a) Student apprentices, who must be of Matriculation or School Certificate standard.
- (b) Craft indentured apprentices, who are usually required to pass an examination.

The *student apprentice* serves a five-year course with one day per week at a recognized educational college, and is trained for admission to a professional institution or for an external degree course.

The *craft apprentice* undergoes practical training for five years with one day per week at technical school, and is trained for the Ordinary National Certificate or the City and Guilds of London Institute Craft Certificates. Some craft apprentices can, of course, reach Higher National Certificate standard, and many do.

Apprenticeship courses in the radio industry usually come under three main headings :—

- (i) Mechanical Engineering.
- (ii) Electrical Engineering.
- (iii) Radio Engineering.

Typical courses for these subjects are as under :—

#### (A) Mechanical Engineering

##### Toolmakers', Machine Setters' Course

These courses are designed to train apprentices in the manufacture of press tools and gauges, etc., and include :

General engineering practice which is common to both courses.

- (i) Bench work and use of tools.
- (ii) Fitting.
- (iii) Drilling and marking out.
- (iv) Machining.
- (v) Centre lathe turning.

##### Toolroom practice (toolmakers)

- (i) Shaping.
- (ii) Grinding.
- (iii) Advanced centre lathe turning.
- (iv) Jig boring.
- (v) Tool inspection.

##### Machine setting.

- (i) Capstans.
- (ii) Press tools.
- (iii) Tool setting.
- (iv) Machine maintenance.
- (v) Auto setting.
- (vi) Inspection.

Selected apprentices spend a few months in the drawing office towards the end of their period of training.

#### (B) Electrical Engineering

##### Electrician's Course

- (i) Bench work and use of tools.
- (ii) Lighting and power circuits.
- (iii) Wiring and soldering.
- (iv) Transformer or power houses.
- (v) Maintenance of test equipment.
- (vi) Wiring and installation of low- and high-frequency equipment.
- (vii) Electrical plant maintenance.
- (viii) Motors and generators.
- (ix) Electrical measuring instruments.
- (x) Telephone circuits.

Selected apprentices serve a period in the plant drawing office towards the end of their apprenticeship.

#### (C) Radio Engineering

##### Radio Mechanic's Course

- (i) Bench work and use of tools.
- (ii) Wiring and soldering.
- (iii) Maintenance and manufacture of test equipment.
- (iv) Wiring and inspection of low- and high-frequency equipment.
- (v) Set inspection and repairs.
- (vi) Set testing.
- (vii) Set fault-finding.
- (viii) Coil and transformer production.
- (ix) Manufacture of valve and h.f. test equipment.

#### 3.2.3. Vocational Training

Arrangements are made in the radio industry to provide facilities each year for a number of specially selected students taking full-time university and technical college courses of degree standard to obtain practical experience in works and laboratories during the summer vacation. This method serves two purposes, it enables the student to supplement his academic studies by some knowledge of industrial and commercial practice, and also enables the firm to find students potentially suitable for employment on graduation.

These students usually take a course of not less than eight weeks and are paid subsistence allowances during the course.

#### 4.0. Supervisory Training

The radio industry is in a constant state of change due to the advancing techniques in the

processes of manufacture, together with the increasing size of workshops and factories requiring new and complicated systems.

Basically the technique of supervision consists in maintaining high standards of quality and quantity.

The radio industry realizing the importance of supervisory training has, in conjunction with the Ministry of Labour and National Service, made available the following courses.

#### 4.1. *Training Within Industry Courses (T.W.I.)*

These courses are designed to lay the foundation of scientific management in an industrial organization, thoroughly and soundly, by training the supervisors themselves to apply the principles of scientific management in their day-to-day work. T.W.I. is based on an analysis of the essential qualities required in the supervisor.

He must have initially :—

- (a) A knowledge of the job, i.e., technical skill.
- (b) A knowledge of his responsibilities within the organization ; and he must also have three skills :
  - (i) Skill in properly instructing those under his supervision ;
  - (ii) Skill in handling workers, i.e., management or leadership ;
  - (iii) Skill in improving working methods.

T.W.I. does not attempt to cover training in knowledge of the work or knowledge of responsibilities, which must be taught within the organization itself. T.W.I. is concerned with the development of the three skills mentioned.

These skills are developed—or at least foundations for their development are laid—in three training programmes :

- (A) *Job Instruction*, which seeks to develop in supervisors skill in giving clear and unambiguous directions and in instructing workers in what they have to do, and how they should do it.
- (B) *Job Relations* training is concerned with developing skill in handling personnel problems in the factory and office.
- (C) *Job Methods* training is concerned with the development, in the supervisor, of the scientific management approach to the improvement of working methods with a view to reducing unnecessary work and hindrances which impede efficient work.

Each course lasts ten hours—five two-hourly sessions given on consecutive days. The courses are conducted on the firm's premises either by a Ministry of Labour trainer or a firm's representative who has been at a Ministry of Labour "institute" as a trainer.

T.W.I. was first originated in this country in 1944 by Mr. Perkins, of the Board of Education, who was loaned to the Ministry of Labour for the purpose. He adapted the American industrial courses to British conditions.

#### 4.2. *Foremanship Courses*

##### 4.2.1. *Industrial Courses*

In conjunction with the Institution of Industrial Administration, the radio industry has designed courses for their own foremen, and lectures and discussion groups are usually given both in work's time and in the evenings. These are given by either outside speakers or selected firms' specialists. The courses usually cover the following subjects : Time and motion study ; Ratefixing ; Safety ; Personnel services ; Production planning and control ; Care of plant and equipment ; Raw material supply and control ; Quality control ; Overheads and costing ; Joint consultation problems and trade union agreements and grievance procedures.

##### 4.2.2. *Ministry of Labour Courses*

The Ministry of Labour, in conjunction with the Ministry of Education, have arranged courses of lectures in Foremanship at various technical colleges throughout the country. The courses normally are of 72 hours' duration and are held in evening meetings of two hours each, twice a week. An examination is taken at the end of each course and a certificate issued. The subjects usually covered are : General Principles of Foremanship and Supervision ; Principles of Production and Planning ; Elements of Labour Management and Costing and Remuneration.

##### 4.2.3. *Technical College Courses*

The Institution of Industrial Administration, in conjunction with technical colleges, have devised a Certificate course in Foremanship. The object of the course is to give foremen and chargehands an opportunity of considering their job in relationship to the modern works organization. The minimum duration of a typical course is two years, during the first year there are approximately 60 meetings, held at the rate of two evenings a week, and in the second year



30 meetings, held at the rate of one evening a week. An examination follows and a pass entitles the student to a certificate issued by the technical institute in conjunction with the Institution of Industrial Administration. The subjects usually covered are the same as those for the Ministry of Labour courses.

#### 4.2.4. Intensive Courses

Full-time courses are run at various residential centres in conjunction with the Management Research Group, British Institute of Management and the National Institute of Industrial Psychology. These courses are of short duration, varying from two-day conferences to three-week courses and the main purpose is rather to create an awareness of the problems involved than to attempt to cover the whole field of any subject.

#### 5.0. Training for Management

Management is both an art and a science. It requires much more than technical knowledge; it demands above all an understanding of human relationships.

To discharge such a task it is most important that a proper training is undertaken.

Management being a subject all on its own, it would appear that it is one which should be taught to men on the job, and not necessarily to university students except as post graduates. It would also seem that a student of management should be either fresh from the workshop or the office, and not fresh from school, and to be of real use the teaching extended to him must correlate principles and theory to the experience which he has already gained.

Following the publication of the Urwick Report on Education for Management, 1947, technical and commercial colleges have set up part-time courses on the lines recommended in the report. Exemption from part of the course is allowed in certain cases, where students have already taken parallel subjects in professional examinations and particularly those taken in the Institute of Industrial Administration Examination.

The course consists of an intermediate certificate which follows the prescribed course extending over three years of part-time study. This is followed by a Diploma in Management Studies, which covers a period of two years.

Other courses qualifying for membership of the Institute of Industrial Administration, the Institution of Works Managers, the Institute of Personnel Management and other professional institutions are available at many colleges. The Institution of Works Managers is shortly publishing a graduate examination syllabus which will cover the whole range of management studies and will be a recognized professional qualification.

#### 6.0. Conclusion

It should not be assumed that the progressive elements in management are content with the foregoing facilities for education and training. There is a growing need—and this need is recognized at the national level—to widen the scope of technological training, including radio, and raise the standard in this country.

In many of the larger companies Education and Training Officers have been appointed to promote and to supervise the training of all grades of staff and to encourage employees to take study courses. These Officers work in close association with the Universities, Technical Colleges and the Professional Institutions in determining and meeting the industrial needs.

National Advisory Councils and professional and educational institutions have been devoting much time and attention to the problem and some of the main recommendations of the Percy Report (April, 1944) on Higher Technological Education are on the point of implementation.

The restrictions imposed on the building of new schools and colleges, and the inadequate numbers of trained teachers and lecturers, are hampering progress. It is fully appreciated, however, by all the interests concerned that the facilities for technical training in this country are not yet available on the lines of those provided by, say, the Massachusetts Institute of Technology. If Great Britain is to retain her traditional eminence in the world's industrial markets it is essential that arrangements be made immediately to meet the urgent educational needs. It is vitally necessary that her scientists, pre-eminent in fundamental research, shall be supported by a highly trained body of technologists who are capable of translating the work of the scientists into terms of goods and services.