BBC

ENGINEERING DIVISION

MONOGRAPH

BRITISH BROADCASTING CORPORATION

MARCH 1957

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ENGINEERING TRAINING IN THE BBC

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FOREWORD

THIS is one of a series of Engineering Monographs published by the British Broadcasting Corporation. About six are produced every year, each dealing with a technical subject within the field of television and sound broadcasting. Each Monograph describes work that has been done by the Engineering Division of the BBC and includes, where appropriate, a survey of earlier work on the same subject. From time to time the series may include selected reprints of articles by BBC authors that have appeared in technical journals. Papers dealing with general engineering developments in broadcasting may also be included occasionally.

This series should be of interest and value to engineers engaged in the fields of broadcasting and of telecommunications generally.

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ENGINEERING TRAINING IN THE BBC

SUMMARY

The constant development and expansion of the sound and television services of the BBC, the introduction of new equipment and techniques in all branches of the organization, and the wide variety of different trades, occupations and professions represented necessitate a sound staff training policy within the Corporation if a high standard of efficiency is to be maintained.

The Engineering Division has its own Training Department, which came into existence some eleven years ago and has been of great service to the Division and the Corporation as a whole in maintaining a steady flow of new, trained staff and in keeping existing staff abreast of new developments.

This review of the Engineering Training Department starts with a brief history of technical training within the BBC, details the types of staff to be trained, and gives a statement of policy. It goes on to discuss training technique, the types of course, and the organization of the Department. It concludes with a description of the facilities available for training and the amenities provided for the students. Six appendices give the syllabus of each course in detail.

1. Introduction

The Government's recently announced plans for developing technological education, if fully implemented, will do much to help this country to keep pace with the efforts of certain other countries to bring their people to a high pitch of technical efficiency. We must realize, however, that these plans only provide the student with the initial technical and, it is hoped, humanistic background to his life's work. They cannot, nor is it desirable that they should, deal with the specialized techniques of the industry he will eventually serve—this is industry's job. The electrical engineering industry has long been conscious of the need for fully trained staff and some of the well-known electrical firms have been pioneers in this field for at least the past fifty years. By comparison the BBC's fifteen years of technical training is short; nevertheless what is lacking in experience may be made up by the breadth of field to be covered, from acoustics to lighting, from heavy to light current electrical engineering at frequencies from 0 to 5,000 Mc/s. A description of the problems which had to be faced and of the way they have been solved may be of interest to those outside, as well as inside, the specialized activity of broadcasting.

2. History

Before the war the BBC Engineering Division had no training department though the need for training was recognized and was met by an *ad hoc* type of 'on the job' instruction. This was due partly to the more leisurely tempo of operations—the first public television service had not yet aroused great public interest, neither had v.h.f. with frequency modulation been considered. It was also partly due to the smaller demand from industry for technically trained men. The BBC could therefore recruit partially trained staff and bring them up to standard by 'on the job' training. At the beginning of the war the armed forces required for their radio communication and radar services just such staff as the BBC possessed and many were called up. Losses had to be made good and the new recruits could only come from the ranks of the unskilled. To cope with this situation a Training Section was started in 1941 and by the end of the war some 2,000 trainees had passed through its hands.

In 1945 a separate department was created and the opportunity taken to assess the probable future trends and requirements of training. During the war much of the instruction had been carried on in small groups at studio centres and transmitting stations in various parts of the country. This had obvious wartime benefits but there were serious disadvantages; a large number of instructors, each working in isolation, was required and it was almost impossible to provide proper facilities on an economical basis. It was clear that centralization was inevitable and essential in order to save dissipation of effort, prevent frustration for the instructor, and to build up a corporate spirit.

Wood Norton Hall, Evesham, shown in Fig. 1, built in 1896 as the home of the Duke of Orleans, pretender to the French throne, had been bought by the BBC in 1938 and equipped with studios, recording and transmitting apparatus for possible use during the war years. Since Wood Norton also had residential accommodation for 100 people it was an obvious choice for a centralized Engineering Training Department and the latter was transferred there in 1946 from its temporary headquarters in Maida Vale. Ten years ago the department was concerned only with training for operational and maintenance work in sound broadcasting; there were two types of course, dealing with new recruits and staff seeking promotion, and a total of 200 students passed through the school in the first year. Some idea of the developments that have since taken place is gained from the figures for 1956 when there were seven types of course attended by 700 students during the year.

3. Training Requirements

3.1 *Types of Staff to be Trained*

The electrical engineering industry recognizes three main groups of staff, the professional engineer, the technician, and the craftsman. The professional engineer is broadly defined as one whose experience and training have fitted him to take executive engineering decisions or to undertake original research work. The technician

Fig. 1 — The main building, Wood Norton Hall

generally acts as assistant to the engineer, carrying out operations, routine measurement, simple design calculations, etc., and in some circumstances taking decisions. The value of the craftsman resides in his manual skill and experience. The BBC Engineering Division contains all these types of staff but in addition it includes an important group known as technical operators whose work requires artistic talent as well as technical skill. The approximate numbers of the different technical categories in the BBC Engineering Division are

Professional Engineers	700
Technicians	1,500
Technical Operators	800
Craftsmen	450

The Engineering Training Department does not undertake responsibility for training the craftsman, who is either given training on the job or is recruited fully trained, but it does deal with the other three types. Before discussing the particular forms of training for the different groups, some statement of policy is desirable.

3.2 *Training Policy*

The aims of training in industry or public service are threefold: to develop the skill and capabilities of staff so that satisfaction in work is maintained, to encourage a constructive attitude to new ideas, and to increase the efficiency of the individual and of the organization as a corporate body. If training is to be successful it must be preceded by a satisfactory recruitment policy, with a training department representative present at interviews to assess the technical standard of candidates. Broadcasting essentially involves team-work so that personality and teachability will tend to be more important than immediate technical knowledge. Chances can be taken with personality for posts involving little contact with others; certain types of research work fall within this category. This method of selecting by teachability rather than technical knowledge—an inevitable result of the nation-wide shortage of technicians—means that there will be widely different standards of technical talent amongst the new recruits. The aims of an initial training course must be to bring the average to a satisfactory standard, at the same time leaving room for help to be given to genuine 'lame dogs' and for encouragement to be given to those above average to go to the limit of their capabilities. It is obviously not possible to do this in lectures, but in laboratory work, exercise classes, and tutorials those students who are below and above the average can be given special treatment provided no more than ten have to be supervised by one man. There will not usually be enough of the extreme cases to warrant separate courses. It is, however, necessary to sound a warning here; above-average staff must be made to realize their limitations, such as lack of practical experience, and not allowed to think that above-average treatment in the training department qualifies them immediately for a higher grade post.

Every attempt must be made to avoid duplicating the work of the universities or technical colleges, but at the beginning of any technical course it will be essential to state and, if necessary, to revise the fundamental principles upon which the more specialized activity is founded. The final objective of the work for which the student is being trained, whether it be research, design, production, operations, etc., must be kept in view, and suitable links must be made with this activity. Thus technical staff in broadcasting must be made aware that their efforts culminate in an artistic production and they must appreciate the aims of the producer and the effect he wishes to create on his audience. Another important characteristic of broadcasting is that interpretation is by ear and eye, and technical students must be made to realize that when there is conflict between objective measurement and subjective sensation, the latter is the final arbiter and the search must be continued for a method of measurement more nearly related to the subjective impression.

When training staff who have had long service with the organization, it will be important to re-establish their confidence in their capability to learn, and this can only be done satisfactorily by knowing their background and building new ideas upon a foundation of their past experience.

The aims of a training department cannot be limited to producing a satisfactory technical standard in its students if it is to be a live organization; it has also to concern itself with personal conduct and especially is this true when courses are residential. It is difficult to lay down rules for achieving the social virtues; punctuality, politeness, consideration for others are all important and of these only punctuality can be fully enforced. The other two can only be effectively attained through the example set by the training department staff.

Besides these general aims there will be others associated with each type of course, but they are best dealt with when describing the detailed work of the department. Before doing this the specialized training technique that has been developed will be discussed.

3.3 *Training Technique*

For a complete understanding of radio engineering a good mathematical background is required and one of the important tasks faced by the Engineering Training Department has been to select and present this highly technical and often mathematically involved knowledge so that it can be readily understood by staff whose duties do not normally call for a high standard of mathematics. Demonstrations during lectures, practical work by students in laboratories, and exercise class tutorials all play a part. Each section of the work is simplified to bare essentials and the mathematical treatment is replaced by pictorial explanation. Every attempt is made at integration so that the student need not feel that he is faced with an impossible task in trying to cover all aspects of his subject. An example is the inter-relationship of phenomena associated with all types of wave motion. The student is first introduced to mechanical wave motion on a stretched string; the standing wave pattern can be converted to a travelling wave (the condition on a correctly matched aerial feeder) by an energy-absorbing frictional termination. The next stage is the water-wave, using a ripple tank; with this apparatus reflection, absorption, and shadow effects can be demonstrated and linked to the action of sound waves in studios and the action of v.h.f. radio waves. The same apparatus can be used to display the sound field pattern of a loudspeaker and the electric field pattern of a slot aerial so that studio and transmitter technicians are made to realize the common features of their work.

With older staff the key-note of the teaching is the linking of new techniques with past experience. For example, it is quite valuable when discussing the difference between frequency and phase modulation to draw attention to the analogy with recording at constant velocity and recording at constant amplitude.

Most courses follow the same pattern of morning lectures and afternoon laboratory work or tutorial exercise classes. An important feature is the twenty-minute question period which begins each day's work. This is taken by the previous day's lecturer, who goes round the class asking questions on the salient points of his subject. The purpose of this exercise is to help the student to realize what are the important aspects of the previous day's work—it is better than a précis recapitulation and keeps the students more alert—and to help the lecturer gauge the measure of his success or failure with the particular class. It is not used as an inquisition to show up the weaker student; those who cannot answer are encouraged to say so rather than to hedge. The lecturer begins his lecture with a brief indication of the ground to be covered and divides it into suitable more-or-less self-contained sections. Each section is covered first and then notes are given on the blackboard. The student can give his undivided attention to assimilating the knowledge without the distraction of note-taking, and the later action of copying the notes helps to fix the information in his mind. Printed lecture notes are only provided on short intensive courses attended by more senior people who are likely to study the information subsequently. Printed copies of complicated diagrams are distributed, but are generally left incomplete so that the student has, under the lecturer's direction, to add notes or label parts of the diagram and is thereby discouraged from being a passive acceptor of information.

The laboratory work may be experimental and designed to establish a principle or it may be operational or fault-finding on apparatus used in the broadcasting service. For this work the students are formed into groups of two, unless the procedure is so complicated or the apparatus so spread out that more than two people are required to carry out the task. When the department was young, apparatus was more limited and groups of three had to be used; this was often unsatisfactory because it encouraged one of the group to be a passenger. Wall charts inform each student group of the work they are doing and where they are to do

it. Printed instruction sheets are issued so that time is not wasted waiting for lecturing staff to be available. The instruction sheet states the object of the exercise, indicates any theory that is required, the procedure to be followed, and the form in which the results are to be presented; it sometimes poses questions. Each student retains the printed sheet and has therefore only to contribute the results and the discussion of them. This uses the limited time available to the best advantage and obviates the profitless copying of already available information. The laboratory books, of necessity in loose-leaf form, are handed in for marking at the end of each experiment.

The apparatus required for each experiment or operational exercise is previously set out by a laboratory assistant, but has to be connected up by the students. As a general rule a fault book is kept in each laboratory and students are instructed to record faulty or sub-standard functioning of equipment. The laboratory assistant

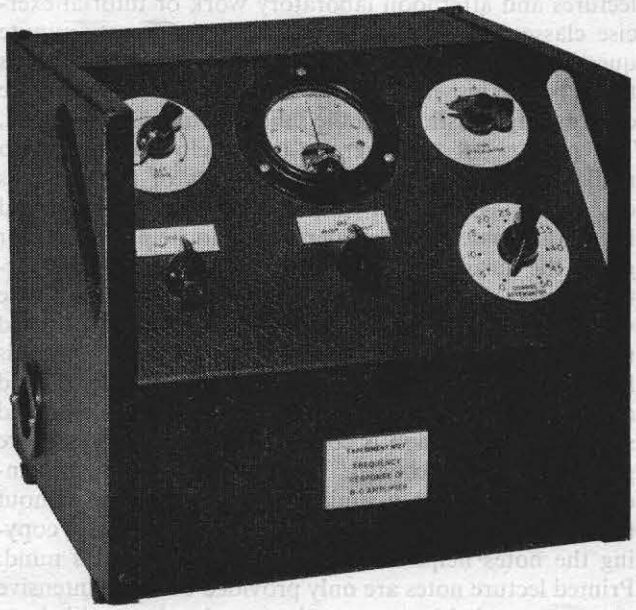

Fig. 2 — The standard chassis

regularly consults the book and is thus able to withdraw the faulty equipment from service and remedy the defect. When no duplicate equipment is available the lecturing staff will try to clear the fault using the students as assistants.

A standard chassis, easily fabricated, has been designed for making up experimental apparatus. A photograph of this chassis is shown in Fig. 2. Its important features are end cheeks which can be mass produced, an open construction with easily traced and accessible wiring and a sloping recessed instrument panel. The length of panel between the end cheeks can be made any required size and the shape is such that it will stand on any of its four sides—an advantage when it is desired to inspect the wiring. The student is encouraged to examine the wiring in order to prevent an experiment becoming a 'knob twiddling' exercise with no understanding of principles; sometimes he is not given a circuit but has to reconstruct it by inspecting the wiring, a procedure made easy by using the B.S.I. colour coding system. All apparatus used by the students is fully finished, spray-painted, and engraved; this is a deliberate policy aimed at making the student aware of the need for neatness, tidiness, and precision in his operational or maintenance duties. When new ideas are being tried out 'bread-board' construction is employed though neat and tidy workmanship is still demanded. As soon as an idea has proved itself a standard chassis form is produced.

4. Types of Course

There are five main types of course: new entry, promotion, specialist, conversion, and workshop. In television the increased complication of equipment and greater operational problems have led to a separation of the two functions, operations and maintenance. This means that for television there are two distinct new entry and promotion courses, one for technical operators and the other for technical assistants (maintenance). Training is also given to certain non-engineering staff known as Studio Managers who are responsible for the balance and control of programmes at studio centres, and there is a special six-week course for graduates in electrical engineering or physics who are undertaking the two-year apprenticeship.

Since all technical staff in the BBC will be using equipment operating at voltages which could produce severe shock and possibly death, it is essential that they should be made safety-conscious. Every effort is made in the design of apparatus to give protection, but in spite of this accidents cannot always be prevented. All students, whatever their age or service, are warned of the special need for care in handling apparatus when under training because the high degree of protection built into operational apparatus cannot always be secured with laboratory equipment. All new recruits are given lectures on safety precautions and are given practice in resuscitation from electric shock using the Holger-Nielson method.

Syllabuses for all the courses, showing the main subject headings and the time allocated for the morning lectures and afternoon practical sessions, are given in appendices I to VI. A week of lectures means five mornings with three hour-long (effective) lecturing periods. A week of practical sessions represents five afternoons of approximately three hours duration. Some explanatory notes on each of the courses are given below.

5. New Entry Courses

At the present time the BBC does not recruit staff for its Operations and Maintenance Departments under the age of about twenty-one, by which age they have normally completed their National Service. The reason for this is that the work requires a degree of responsibility not always found in the sixteen to nineteen year olds, who also are not

permitted to rotate on the shift system employed in the BBC; the isolated position of many transmitting stations makes difficult a satisfactory system of release for training at a technical college. These arguments do not apply to certain specialist departments engaged on research or design, and youngsters of sixteen to eighteen are occasionally recruited as trainee technicians and encouraged to train by part-time study for the Higher National Certificate or an external degree.

The new recruit to operations and maintenance departments is given a two-week induction course in London organized by the Engineering Establishment Department. The theme is BBC organization and procedure, and conducted tours of the London sections of engineering departments are arranged. The recruit is then sent as a probationary technical operator or assistant to the department for which he has been selected; here he has an opportunity of absorbing the atmosphere and of carrying out operational or maintenance work, or both, under close supervision. After three to six months' service he is sent to the Training School at Wood Norton where he takes a technical operators' course if he is in television, or a technical assistants' course if he is in sound. All television technical staff take the initial technical operators' course since a final decision on whether they will specialize in operational work or maintenance is not taken until they have completed a year's service. Those television staff who are to specialize in maintenance work then join a technical assistants' course having the same Part I as the sound staff, but a different Part II specializing in maintenance of television studio or outside broadcast (radio links) equipment.

5.1 *New Entry Technical Operators' Course*

This course lasts for six weeks and its purpose is to give the student a working knowledge of the system (mainly through block schematics), the vocabulary of technical operations, and some idea of the artistic problems of lighting and picture composition. During the practical periods, simple experiments dealing with the elementary principles of sound, electricity, and optics are performed as indicated in Appendix I. One of the experiments is to measure the aural sensitivity of each student, an important test for those who may specialize in sound. The picture composition and lighting experiments are intended to indicate latent artistic ability, and inculcate critical observation of a scene. The first objective is achieved by giving the student geometric shapes which he has to

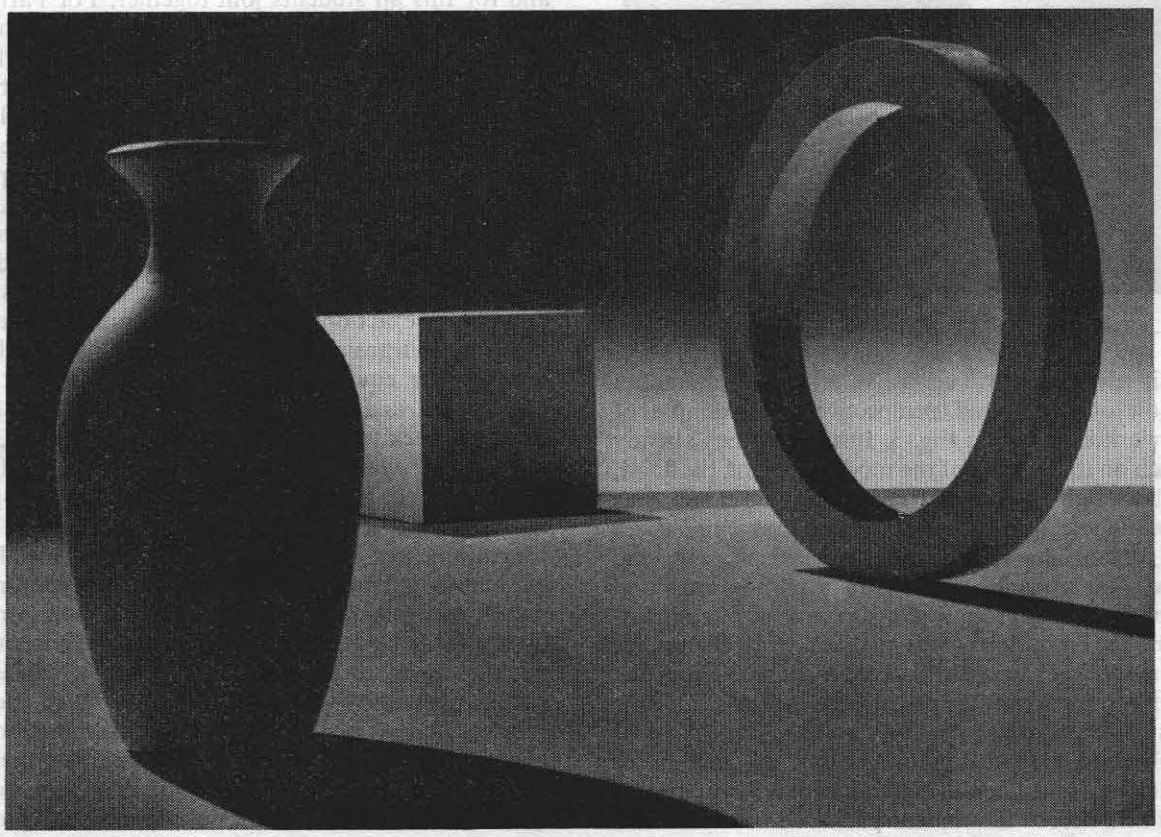

Fig. 3 — An example of student work in lighting

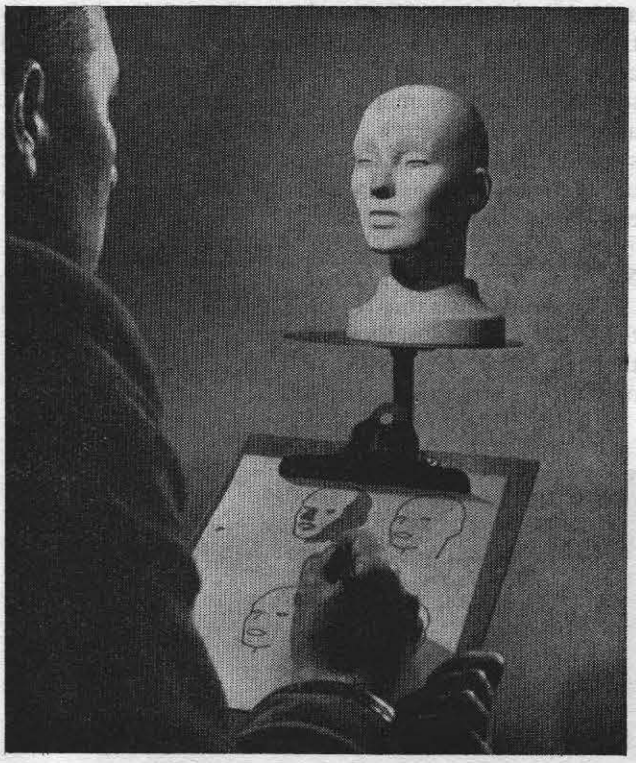

Fig. 4 — Sketching the effects of lighting on a model head

arrange in a way that will secure an artistic effect and an impression of depth and perspective; an example of student work is shown in Fig. 3. Instruction has already been given on the placing of the modelling light, the flood, and the back light. The use of a photographic camera has two advantages; it provides a record and emphasizes the need for considering camera position when composing a picture. The student prints his own photographs and this helps him to appreciate the significance of contrast, range, and the limitations of his medium. Critical observation is encouraged by requiring the student to examine the effects of lighting a model head as seen in Fig. 4. Outline sketches of the head are provided and the dark parts of the face have to be shaded in for a number of positions of the modelling light. Portrait lighting with a live subject is the final task before the student passes on to the camera channel where he gets experience in setting up and making adjustments to the lighting and camera controls to get best results on the picture monitor. He notes the difference between what the eye sees of the scene direct and what it sees on the picture monitor, and discusses the reasons for the difference.

The Training Department report on new entry staff may well be decisive in determining whether an individual is retained in the Engineering Division, so that great care must be taken in reporting. Some uniformity of judgement is ensured by having six items on which particular comment is required. They are technical background, artistic ability, theoretical ability, operational, practical and written work, industry and application, and personality. Also included is a composite assessment, which indicates any outstanding qualities the new recruit possesses, and the category of staff, technical or operational, into which he might best fit. If he is recommended for operations an indication is given whether he possesses creative ability in picture composition and is therefore best suited for camera work, and perhaps later for lighting, or whether he would be better employed on vision control apparatus where technical interest as well as manual dexterity is important.

5.2 New Entry Technical Assistants' Course

The course is divided into two parts. Part I deals with the radio engineering fundamentals which must be known by all technical staff engaged in broadcasting engineering and for this all students join together. For Part II they separate and engage in their specialist activity, which may be any one of the duties shown in Appendix I. The afternoon work in Part I is divided equally between laboratory experiments and tutorials with exercises and simple wiring and workshop procedure. At the end of Part I the student is given a preliminary examination and his paper is returned to him so that he can study the marking and check the standard he has reached. The emphasis in Part II is on operational work with apparatus the student will eventually be using. It is not possible in every instance to provide the exact operational equipment. For example, a high-power transmitter would be uneconomical, and a lower-power equivalent (7-kW) enables almost all the operational and testing procedure to be undertaken. Routine check tests and elementary maintenance, such as cleaning of switch contacts and replacement of valves, are a part of the training. In order to inculcate 'programme sense' all new recruits have to play their own part in a test programme just before the end of their course. The programme is initiated from studios and outside broadcast points, controlled, distributed, recorded, and transmitted by the students all working as a team. An examination takes place at the end of Part II and it consists of a written paper of two hours' duration on Part I and Part II subjects and a practical operational examination lasting about half an hour. During the practical test the student is timed and faulty operation noted. Afterwards he is quizzed on the reasons for his operational procedure. Success in this examination leads eventually to establishment, and failure to termination unless there are any extenuating circumstances. The progress of a student throughout the course is watched closely and those who seem likely to fail are warned at the end of Part I that extra effort is needed. The failure rate is about 3 per cent.

The procedure for reporting on a student is the same as that outlined for new entry technical operators. Artistic ability is replaced by operational ability, all the other headings being the same. The general comments include a statement on the student's promotability, indicate any outstanding ability he may possess, and recommend a change of work if this seems in his and the Corporation's interest.

6. Promotion Courses

The new entry training fits staff for the day-to-day routine operational duties, but in the time available it is not possible to lay a foundation of technical knowledge which is adequate for solving all the problems encountered by technical assistants as they progress in their career. Junior staff are therefore given the opportunity to enter for a more advanced course which fits them for promotion in the operations or maintenance fields. They are expected to bring themselves to a satisfactory standard by their own efforts through home study, correspondence course, or technical college course, and they are not accepted unless this has been done. As would be expected, technical operators have a different course from technical assistants. The promotion courses described below are normally taken after some years' service to qualify for promotion to the engineer or senior operator grades.

6.1 *Television Technical Operators' Course*

This takes place after the operator recruit has had at least four years' experience on the studio floor. Entry to the course is dependent on recommendation by senior supervisory staff who have to satisfy themselves that the applicant is suitable to take charge of juniors and is up to a satisfactory technical standard. The twelve-week course (Appendix II) is divided into two parts, the first five weeks are spent on fundamentals and the remaining seven weeks on practical applications. The experiments in Part I are designed to give familiarity with the tools of the trade, photometers, light meters, lenses, etc.

During the early part of picture composition and lighting instruction the photographic camera is used, and developing and printing is carried out in the fully equipped darkrooms. The aim is to light for perspective depth, contrast, and shape, i.e. to produce the impression of three dimensions in a two-dimensional medium. There is an orderly progression from simple to complicated scenes; portrait lighting is followed by the two-person interview involving careful placing of the microphone so that neither it nor its shadow is ever visible. Before attempting lighting with life-size sets in which the television camera is involved, experience is obtained on model sets with small easily positioned lighting units, with which all the basic effects of indoor lighting, sunlight, moonlight, etc., can be tried out. In the final exercise with television cameras, scene illumination ratio is measured and compared with the image illumination ratio on the monitor picture tube screen. Since sound quality and perspective are also important, part of the practical time is devoted to determining the directional characteristics of microphones used in the television service, and to methods of producing special effects, such as telephone-quality speech and artificial reverberation. The course needs to have a down-to-earth outlook and to this end producers in the different types of television programme, and experts in lighting and sound reproduction, are invited as guest lecturers.

The course concludes with an examination consisting of two two-hour papers, one on the fundamentals of optics, sound, and electricity, and the other on television camera and sound equipment and on lighting and picture composition. Apart from requiring a knowledge of the principles of good picture composition, questions on this subject are illustrated by photographs having defective composition and the candidate has to analyse the defects and suggest remedies. There is no pass-fail mark in this examination but the student's mark is recorded on his training report. The latter contains general comment and the same sub-headings as the report on the new entry technical operator. No reference is made to personality unless there is some special reason for so doing, because it is assumed that service will have been long enough to show that this is satisfactory.

6.2 *Technical Assistants' Course*

The technical standard of the applicant for this course must be much higher than that of the technical operator, and to ensure that he has reached this standard he is called to a half-hour interview, during which an oral technical examination is carried out. Some idea of the standard required is given by the exempting qualifications, Ordinary National Certificate in Electrical Engineering or Intermediate Certificate in City and Guilds Telecommunications Course. These promotion course syllabuses (Appendix II) have a pattern with some resemblance to the initial entry courses; they last twelve weeks and the time is equally divided between a fundamental Part I and a specialist Part II covering the same groups of staff as the new entry courses. There is a written examination at the end of the course with two papers each of three hours' duration, one on Part I and the other Part II. Success in both parts opens the way to full promotion but success in one part gives promotion into the next grade only. Failure means that staff remain at their present grade.

The lectures in Part I are intended for revising already known theory, and for breaking new ground in knowledge which will be required by staff irrespective of their specialist activity. Examples are the network theorems, series-parallel circuit conversions, etc. Afternoon work is divided between the laboratory and tutorial exercise classes. Considerable attention is paid to the discussion of results following on the laboratory work and endeavours are made to develop in the student a feeling for concise and accurate reporting. The exercise class period is used to link the theory with practice through numerical examples on typical circuits used in broadcasting. Past examination papers are also worked over, and the student is occasionally given the task of writing an instruction for junior staff who are to carry out a given test. The main difference between the method of attack in this course and that in the new entry course is that this one tends to be analytical in approach, stressing the 'why' rather than the 'how' it works.

The lectures in Part II show the application of the fundamental theory to practice and analyse the performance of the broadcasting apparatus the student is called upon to maintain and operate. Similar lectures required by more

than one group are given in combined classes. The practical work can be conveniently divided into tutorials with exercises, operational procedure, and maintenance, the proportion of time devoted to each depending on the group activity. Fault finding and fault clearing is an important part of the work.

It is proposed that the duties of operations and maintenance shall ultimately be separated from each other in sound studios and recording and when this occurs there will be separate courses. The new studios and recording operations course will be nearer to the form of the television operators' course.

Certain external qualifications themselves give entry to the promotion grade in Operations and Maintenance Departments; they are

- Graduateship of a British University in Electrical Engineering or Physics
- Graduateship of the Institution of Electrical Engineers
- Graduateship of the British Institution of Radio Engineers
- Higher National Certificate in Electrical Engineering
- Full or Final Technological Certificate of City and Guilds Telecommunications Course.

Staff with these qualifications are generally required to take Part II of the promotion course as this deals with broadcasting equipment and technique which cannot be a part of the syllabus leading to an academic award.

Those who have no external qualifications, and who have secured a high place in the promotion examination, are eligible to be considered for a place in a Higher National Diploma Sandwich Course. Four such awards are granted every year.

The final report on students contains the Part I and II examination marks as well as the general assessment and the sub-heading comments on technical background, theoretical ability, practical and written work, and industry and application. A sub-heading on personality is not regarded as necessary.

7. Graduate Apprentice Courses

The graduate apprentice course is of two years' duration involving attachment to other departments as well as the training department. Its purpose is to produce a well-balanced man of wide experience who will eventually qualify for corporate membership of his appropriate professional institution. The BBC scheme does fulfil the practical training requirements of the Institution of Electrical Engineers; it includes a period spent in the works of manufacturers with whom special arrangements have been made. Two types of graduate are involved, one intended for specialist departments concerned with research and design, and the other for Operations and Maintenance Departments. The qualities required of the two types are quite different.

The specialist department graduate should have an honours degree (1st or 2nd class), and if he is to undertake research he should be capable of independent work, be interested in examining the possibilities of an idea, rather than its subsequent development. To be successful in design work the graduate needs to be capable in small-scale construction, have a good knowledge of circuitry, and like to see his final result in a workable form. He is essentially a doer compared with the research thinker. The recruit to Operations and Maintenance must be a good mixer, have a quick and agile mind, be cool in an emergency, and have an automatic and controlled reaction. He must be quick to profit by past experience and to link cause and effect. This type will mostly be found in the ranks of the pass degree men.

The Institution of Electrical Engineers sees a graduate apprentice course as divided into three phases, a basic workshop training period of from three to four months, general electrical and mechanical engineering training for from eight to twelve months, and directed objective training on work allied to that in which the graduate will eventually specialize. The BBC conforms to this plan as shown below.

Phase	*Department*	*Specialist*	*Operations and Maintenance*
Basic (Workshop)	Manufacturer	3 months	3 months
General	Equipment Planning and Installation	1 month	3 months
	Manufacturer (assembly and test)	3 months	3 months
	Operations and Maintenance	4½ months	none
Directed Objective	Training	1½ months	1½ months
	Designs	5 months	none
	Research	5 months	none
	Operations and Maintenance (General)	none	4½ months
	Operations and Maintenance (Specialized)	none	6 months

The above does not necessarily represent the chronological order of the plan; in actual fact the one and a half months' functional training given in the training department is normally the start of the course.

The purpose of the six months with a manufacturer is to give workshop experience and some idea of production methods and problems. The four and a half months spent in the Operations and Maintenance Departments is intended to give the specialist an appreciation of the problems and requirements of the people he is to serve, so that he will be more likely to produce an answer which is comprehensible or apparatus which is usable by the Operations and Maintenance staff.

The operations and maintenance graduate is given four and a half months' general experience in almost all departments concerned with this work before settling in the department of which he will eventually become a member.

The syllabus of the one and a half months' functional training is shown in Appendix III. The lecture course introduces both types of graduate to broadcasting operations, dealing with any fundamental specialist theory that may be required. The two types separate for practical work. With the specialist graduate the aim is to bring him to an ade-

quate pitch of operational efficiency so that he can make the fullest possible use of the time he spends in the Operations and Maintenance Departments; he is therefore given practice in operational procedure in transmission, studio, and recording work. The aim with the operations and maintenance graduate is to give him a good knowledge of the theory of the apparatus which he will use, because a high degree of operational skill and maintenance knowledge will be developed during his six months' directed objective training. The difference in treatment can be illustrated by reference to transmitter training; the specialist graduate gets practice in setting up the programme input equipment and in getting a transmitter run up to full power, whereas the operations and maintenance graduate makes measurements and calculations on the output tank circuit and its efficiency.

At the end of the course both types of graduate combine in a programme exercise in which they play the part of artists, producer, and technicians. Reports, submitted on each graduate when leaving a department, are in the form of composite assessments and are not accompanied by sub-heading divisions.

8. Studio Managers (Sound)

These staff are responsible, among other things, for determining the best position for the microphone in the sound studios and for keeping programme volume within limits such that quiet passages are not marred by noise and loud passages do not cause overloading at the transmitter. The control of volume should naturally give the best artistic effect, and the problem is complicated by the fact that an illusion of binaural listening has to be created out of a monaural system. Some studio managers have a good technical background, but many are recruited for their specialist knowledge in modern languages, music, etc. The task of the Training Department is to give them sufficient technical background to carry out their work with understanding so that the limitations of the medium are minimized, or in some cases exploited, so as to achieve a satisfactory aural perspective. The syllabus includes lectures from visiting specialists in studio apparatus design, microphone usage, studio acoustics and recording developments as well as from producers of the various types of sound broadcast programmes.

The practical work emphasizes the importance of wavelength in determining the performance of microphones and loudspeakers, and the influence of the directional characteristic and placing of the microphone on the quality of the transmitted programme. The electrical experiments are intended to give a working knowledge of the valve and the consequences of harmonic and bass or treble distortion. The action of linear and logarithmic faders is dealt with aurally as well as electrically.

No examination is held at the end of this course but a very full report is issued on each candidate with special reference to his initial technical standard, application in lectures, and practical work and progress throughout the course.

9. Conversion Courses

These are intended to fit staff for transfer from one group to another. When only one or two people are involved, they are attached to the appropriate Part II of either the New Entry or the Promotion Course. Much larger numbers have been involved in the transfer from Sound to Television, and a special course at two levels, preliminary (equivalent to New Entry Part II Television Studios, seven weeks) and advanced (equivalent to Promotion Part II Television Studios, six weeks), has been instituted. The practical work has tended to be of a hybrid nature consisting in part of operational training and in part of maintenance. This has been due to the fact that it was not known at that stage in which sphere the staff would specialize.

10. Specialist Courses

These have varied from the refresher type for bringing staff up to date to the type introducing them to new developments. Two examples of the latter are the Frequency Modulation Course for engineers-in-charge of the v.h.f. transmitting stations, and the introduction to colour television for senior technical staff. Both courses are limited to a week and the syllabuses and practical work are shown in Appendix V. Other courses are arranged as required and the Field-strength Measurement Course given in the same appendix prepares technical assistants for undertaking this task.

11. Workshop Course

This course (see Appendix VI) is an intensive one of six weeks' duration intended for staff who have shown a special aptitude in maintenance repair work. The lectures are spread throughout the whole course but are equivalent in time to a week of mornings; the remaining five weeks are used for practical instruction, covering the use of all the normal hand tools, the lathe, and drill grinder. In each exercise the student makes a tool, which, except for one specimen retained in the department, he takes with him at the end of the course. This encourages the student to take a pride in his work since these tools are likely to be used on his return to normal duty. In addition to the tools a small toolbox has to be constructed and this involves practice in bending and soldering tin sheet. On an average six of the eight hand tools and one of the lathe-made tools are completed.

12. Organization of the Department

12.1 *General*

The organization of the department is best illustrated by reference to the family tree shown in Fig. 5. There are three main branches: Instruction, General Administration, and Instruction Writing. The first two concern the Wood Norton School. Instruction Writing has to be near its sources of information, the specialist departments, and is therefore located in London. There are four instructional sections: Fundamentals, Studio and Recording, R.F.

Transmission, and Operations, each in charge of a senior lecturer, assisted by lecturers, lecturer-demonstrators, and laboratory assistants. The senior lecturer is responsible for all the work of his section, for planning his laboratory and operational equipment areas, for installing new apparatus, for preparing examination papers in collaboration with his lecturers, for co-ordinating the reports issued on the progress of every student, and for the wise spending of the annual grant made to his section. The annual grant for new equipment is supplemented by redundant experimental equipment and prototype models from other departments. Expensive items of complete equipment like a camera channel, a recording channel, etc., are the subject of special financial allotments outside the annual grant. Each lecturer is generally a specialist in a particular branch of broadcasting engineering and he is responsible for the detailed implementation of training in that activity, the development of suitable laboratory experiments, and the pioneering of new methods of presentation. The lecturer-demonstrator's main function is to help in the laboratory work and operational teaching; when first recruited he may have little experience in lecturing and his lecturing duties will be very limited. He is given help and encouragement in learning that side of his work so that he may be available for promotion when the opportunity arises.

The laboratory assistant has to help in maintaining all the operational equipment in a satisfactory condition, in seeing that laboratory apparatus is in working order and that it is placed ready for the student to connect up, and in constructing demonstration apparatus. He may be either a skilled mechanic or a technician; in the latter case, he is selected from comparatively young technical assistants in the operating and maintenance departments and is encouraged to prepare himself for taking the promotion course and returning to a higher grade post in his original department. There is no promotion to lecturer-demonstrator direct from laboratory assistant. This does not mean that there is scope only for a man having high academic qualifications; wide practical experience in broadcasting engineering can be more valuable for operational training than academic attainment. Of the twenty-three teaching posts, nine are filled by university graduates, five by those with equivalent technical qualifications (Higher National Certificate, etc.), three by men of wide practical experience; the remainder are preparing themselves by evening study for the Higher National Certificate.

The Engineering Establishment Department acts as the co-ordinator of requests for training courses and it advises on the selection of the staff who are to attend the Training School. Close liaison is maintained with the Training Department to try and level the load of training, not only in terms of total numbers, but of numbers in the various sections. Even so it has sometimes been necessary to accept only two students on a given course. In order to use training manpower economically under variable loading conditions, all staff in a given section must be capable of helping in other than their specialist activity and lecturers are expected to have a wide technical background. In some instances it has been necessary to transfer staff temporarily from one section to another.

A problem facing any training department is the extent to which it will use guest lecturers from other departments. There are two disadvantages to their use; the first is that

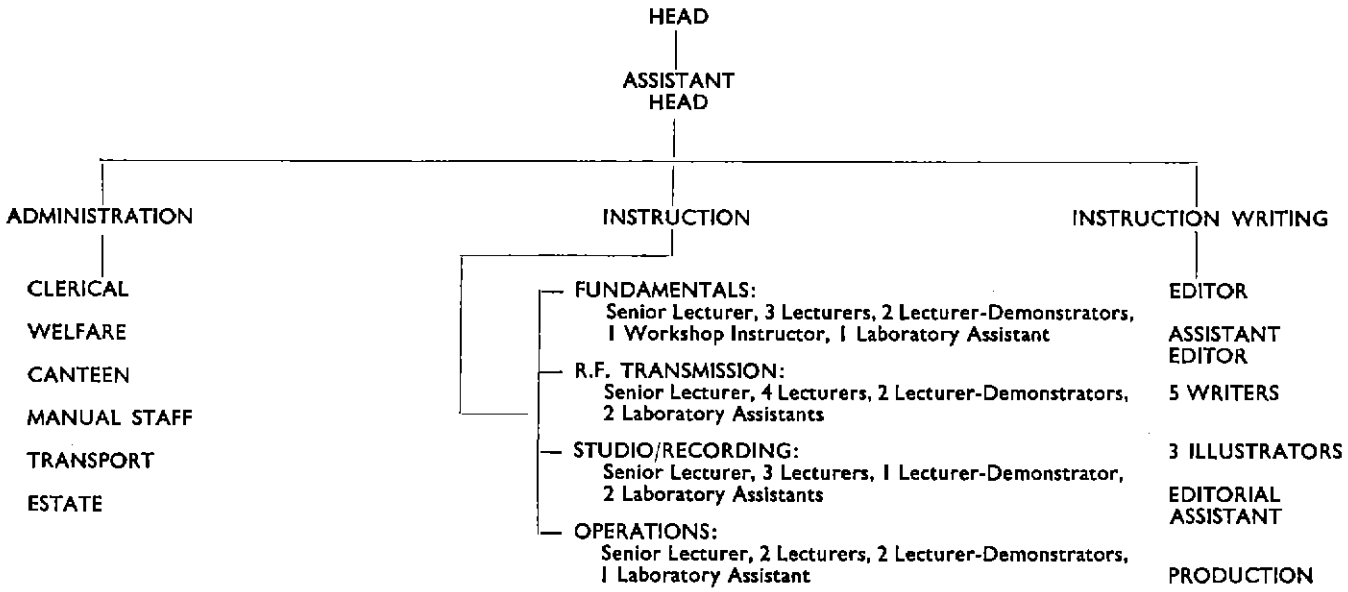

Fig. 5 — Engineering Training Department — Organization Chart

the expert may lack teaching ability or may assume a better knowledge on the part of his audience than is justified; and the second is the waste of the expert's time in travelling. The Engineering Training Department of the BBC has found it preferable to send its staff to gain the technical information themselves rather than use guest lecturers. An exception to this rule is for the operational courses when the expert is required to answer questions as well as pass on his personal experience, or when matters of opinion rather than fact are involved.

In broadcasting, techniques are constantly changing and teaching staff must be given an opportunity of keeping up to date. Every effort is made to give lecturers and lecturer-demonstrators at least two weeks per year in some other department, or, when appropriate, in an organization manufacturing broadcasting equipment.

An important aspect of the work of the Training Department is the production of fair and accurate reports on students, for these reports may well decide their future progress in the organization. Each lecturer is required to put in a report on the students under his care to the senior lecturer, who then combines all these views into a single concise report. When there is a conflict of views it will normally be resolved by a meeting of the lecturers with the senior lecturer. Senior lecturers pass advance information to the Assistant Head of the Department on students whose progress continues to be unsatisfactory; if he decides that there are no extenuating circumstances he will administer an official warning that an adverse report will be issued if an improvement does not occur. An adverse Training Department report on a new entry student generally means termination.

12.2 *Fundamentals Section*

Turning now to the detailed work of the school, the Fundamentals Section serves the other three by dealing with the fundamental knowledge required by all technical staff irrespective of the particular work upon which they are engaged. Thus it deals with the fundamental principles of optics, sound, and electrical engineering necessary for broadcasting. This is an economical arrangement for it saves duplication of effort in the sections and it has the advantage of bringing all students together for part of their training, thus tending to promote the team spirit which is so important in broadcasting. One of the members of this section acts as general editor for all the examination papers and fair answers issued by the department.

12.3 *Studio and Recording Section*

The Studio and Recording Section deals with training for the operation and maintenance of studio control rooms and recording channels, as well as for work connected with music lines and the BBC communication system. It is responsible for the servicing of all the audio-frequency equipment in the department; this explains why it possesses two laboratory assistants.

12.4 *Radio Frequency Section*

The Radio Frequency Section is concerned with the training of staff for the Transmitter Department, the Tatsfield Monitoring station, Television Outside Broadcast Department (including radio links), and Television Studio Maintenance. The maintenance of television camera channel equipment used by the Operations Section is its responsibility, and for this reason there are also two laboratory assistants in this section.

12.5 *Operations Section*

All the technical training for television operations and studio managers is undertaken by the Operations Section. One of the lecturers is a photographic expert well versed in the problems of lighting and picture composition. The laboratory assistant maintains the studio lighting equipment and is steward for the three dark-rooms used by the television students for their photographic work.

12.6 *Administration*

General administration at the school is in charge of an administrative assistant, who controls clerical, welfare, and manual staff. Clerical staff form a 'pool' for dealing with reports on students, technical reports, laboratory experiment sheets, fair answers to questions, financial returns, allowances to students, etc. Three secretaries are used for all confidential work. On the welfare side there is a warden and full-time resident nurse. The warden arranges for games and recreation and acts as guide, philosopher, and friend as well as upholder of the rules and regulations essential in a residential training establishment. The gardeners provide vegetables for the canteen and also keep the ornamental grounds tidy. The 100-acre estate belonging to Wood Norton Hall is mostly woodland. A transport system to and from the nearest town, Evesham, three miles distant, is operated for staff and students. The manual staff under a house foreman are responsible for maintenance of all electrical, mechanical, water, and sewage equipment as well as for cleaning and stoking duties.

12.7 *Technical Instructions Section*

The Technical Instructions Section consists of an editor, assistant editor, and five writers together with three illustrators, typists, and a small production unit for distribution and for printing certain of the instructions. The writers are trained and experienced engineers with an ability to write clearly and concisely. Though they are versatile there is a tendency for them to specialize in one particular activity; thus one writer may deal with all transmitter power circuits, another with sound studio and recording equipment, and another with television studio apparatus.

The section produces training manuals in collaboration with other departments and training supplements in association with the school. The latter are booklets on subjects of immediate importance to staff and on new developments. Subjects such as television lighting, frequency modulation, and slot aerials have been covered.

These booklets are issued free on request to all technical staff in the BBC. This section is also responsible for specialized service instructions on drawing-office practice, safety regulations, valves, etc. For instructions running to 1,500 to 2,000 copies an order for letterpress is placed with a printer, but when the required number is only 200 to 300, the instruction is typed direct on lithographic plates, from which the necessary copies are produced in the section.

13. Training Facilities and Laboratories

13.1 *General*

Owing to the specialized nature of the instruction given during Part II of the New Entry Technical Assistants' and Promotion Courses, there are often from five to six specialist groups to a given course, and the ten lecture rooms available are generally fully occupied. The largest can accommodate seventy, the second largest forty, but the majority seat about twenty; seven lecture rooms can be 'blacked out' when a projector is to be used. Besides two projectors for $3\frac{1}{4}$-in. $\times 3\frac{1}{4}$-in. slides, a 35-mm projector is available with a portable screen; film strips are rarely used because they tend to place a lecture in a strait-jacket. A 16-mm sound projector is used in a special viewing room seating about thirty. All lecture rooms have an adequate number of 5-A, 230-V a.c. mains outlets, and the principal ones are fitted out with programme lines for sound and vision. Trolleys are used for demonstrations requiring a large amount of apparatus.

13.2 *Fundamentals Section*

The Fundamentals Section has three laboratories, one each for elementary and advanced electrical and radio experiments and one for optics. A view of one end of the advanced laboratory is shown in Fig. 6; each numbered bench position corresponds to a numbered experiment, marked up on a wall chart indicating to the student group the experiment they are to undertake. Each bench position has its own power and mains supplies of 230-V and 6·3-V a.c., and 250-V d.c. with safety plugs and sockets to prevent accidental contact by the student. There are, in addition, ring mains carrying low-voltage high-current a.c. and d.c. supplies, and 250-V 0·5-A stabilized d.c. circuit-breakers with overload trips and warning lamps quickly indicate to the lecturer-demonstrator any circuit that has been put out

Fig. 6 — One end of the advanced laboratory

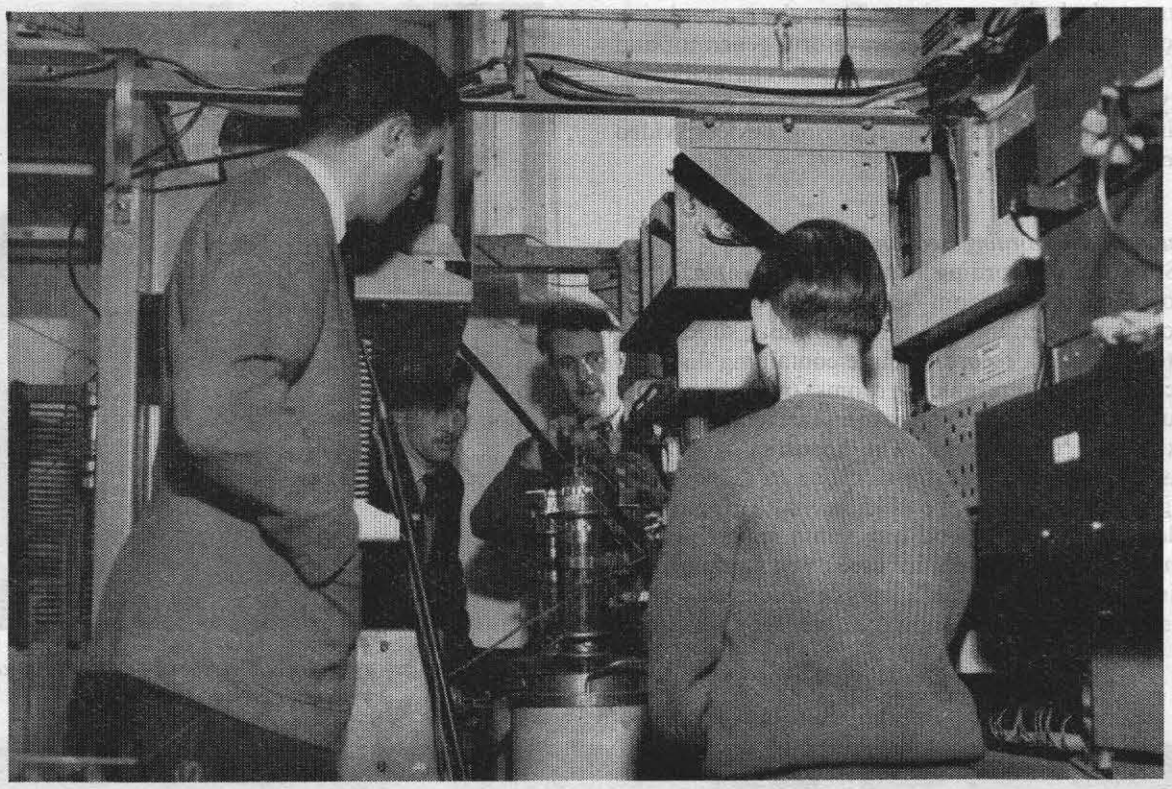

Fig. 7 — Transmitter staff receiving instruction on an air-cooled medium-wave transmitter

of action by a wrong connection. The optics laboratory is equipped for practical work on lenses, and for photometric and colorimetric measurements. It is mainly used for television operators and for the specialist Colour Television Course.

Demonstration equipment is available to show many fundamental radio principles, among which may be cited, wave synthesis, r.f. spectrum analysis, valve load lines for class A, B, and C operation, and diode detection. The wave synthesizer has a fork-stabilized 250-c/s fundamental and up to the 10th harmonic. The amplitudes and time displacements of each component can be varied to produce a square, triangular, sawtooth, or half-sine wave shape, or to synthesize an a.m. or f.m. wave. The r.f. spectrum analyser enables the frequency spectrum of any type of modulated wave to be examined over a frequency range of 100 kc/s for modulation frequencies of 2 kc/s or over, and carrier frequencies up to 20 Mc/s. The valve load line apparatus shows the increase in load impedance due to the addition of a second valve in a push-pull circuit, the curvature in load characteristic when operating in class B, and finally the discontinuous characteristic of class C operation. The detection equipment indicates the functioning of a diode detector, the distortion due to overmodulation and 'non-tracking', and also the effect of component values on performance. In addition there are many demonstration boards with large-scale circuit diagrams in front and powered circuits behind to illustrate valve amplification, negative feedback, input impedance of a cathode-follower, etc.

13.3 *Transmission Section*

The Transmission Section possesses two large laboratories, devoted to aerials and r.f. measurements and to pulse equipment and television waveform measurements, also two smaller laboratories, one housing a 1-kW medium-wave transmitter and programme input equipment and the other a 7-kW air-blast-cooled transmitter, a view of which is given in Fig. 7. This transmitter supplies power either to a dummy load or through feeders to an aerial termination hut where the feeder can be matched to an outside aerial. A fifth laboratory is devoted to practice in maintenance of r.f. and vision-frequency equipment. The aerials laboratory contains equipment for showing the propagation characteristics of medium-wave broadcasting aerials, and v.h.f., television, and frequency modulation aerials. Scaled-down models operating at about 150 Mc/s are used for this purpose, and also for showing current distribution. There is an ionospheric simulator to show the effect of the anti-fading aerial, and a model short-wave oversea broadcasting array on which can be illustrated electrical slewing of the beam. R.f. bridge measurements and the matching of transmission lines to feeders are carried out here, as well as measurements on

a.m., f.m., and television receivers. The pulse transmission laboratory contains a television waveform generator and apparatus for measuring rise time, and the characteristics of all types of television circuits—blocking oscillators, delay lines, d.c. clamping and restoring devices, video amplifiers, etc.

13.4 *Studio and Recording Section*

The Studio and Recording Section is responsible for the eight-position control room—each position can accept four incoming programmes—two continuity suites with associated studios, a recording suite containing disk and tape recording and reproducing rooms, two laboratories for acoustics and for microphone measurements, and also an inexpensive 'dead' room. The acoustics laboratory contains a mechanical transmission line to demonstrate standing and travelling wave phenomena, a ripple tank to display the effect of sound waves in a studio (scaled-down models of studio walls are used), and equipment to determine the absorption coefficients of various materials. Demonstration equipment shows the break-up of a loud-

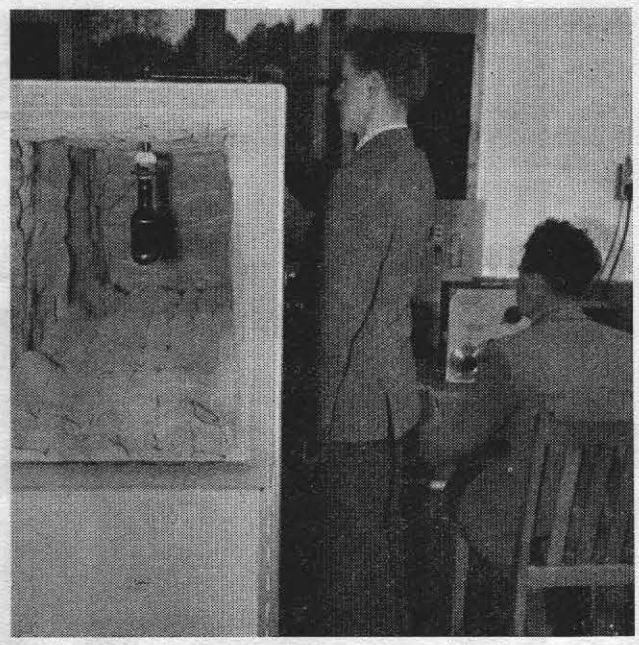

Fig. 8 — Measuring the directional response of a microphone in an acoustic duct

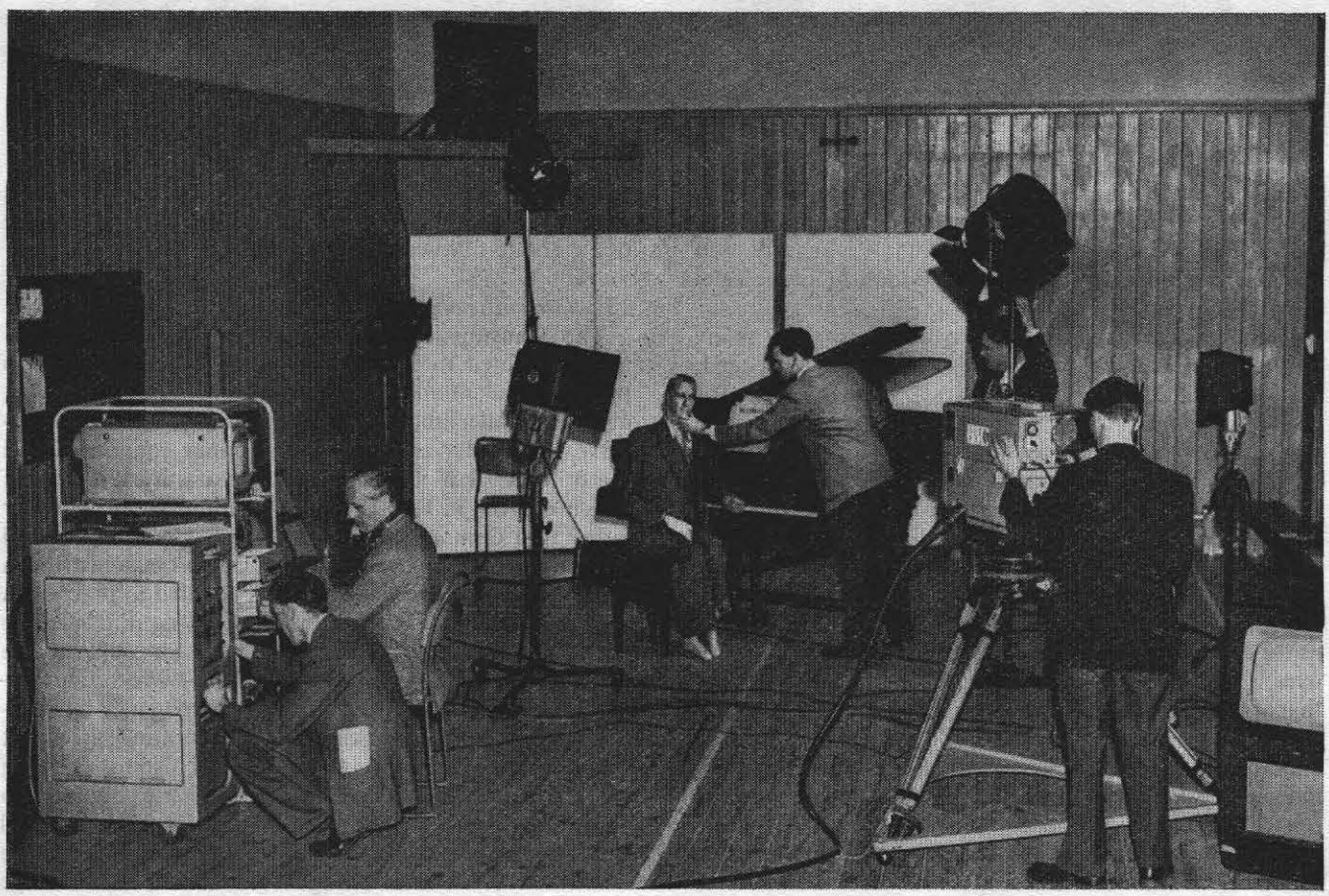

Fig. 9 — Part of the television studio used for instruction in camera operation and lighting

speaker cone at various frequencies and a probe microphone is used to explore vibration over the whole cone surface. An electrical simulator illustrates the action of cone corrugations in increasing the loudspeaker response at high frequencies. The similarities between sound and electromagnetic waves are shown by a sound transmission line, a 3-in. metal tube, with a small loudspeaker at one end and a microphone at the other. A short closed-end piece of 3-in. tubing is screwed into the side of the tubing until the sound transmission is almost completely cut off. The short piece of tubing acts in the same way as the short-circuiting stub sometimes used on radio frequency transmission lines for suppressing harmonics of the transmitted frequency. The microphone measurements laboratory contains correctly terminated ducts into which the microphone is inserted so as to give a good approximation to free-space conditions. One such duct is shown in Fig. 8. There are in addition two rooms used for programme-input apparatus and line testing, and a moderate-sized studio and its associated control cubicle, which are used for mock programmes and occasionally for television camera work.

13.5 *Operations Section*

The Operations Section has a lighting laboratory, where the principles of lighting and picture composition are learnt, and two studios, one for studying the effect of the camera tube characteristics on the final picture using a type of image iconoscope camera, while the other, equipped with an image orthicon camera, contains basic sets which have to be lit with movement in mind. Fig. 9 shows students working on one such set. There are three dark-rooms fully equipped for developing and printing the photographic records made by the students in the early stages of their course.

Apparatus is therefore available to make up and carry out multi-programme operations upon the complete sound broadcasting chain from microphone to aerial including recording and outside broadcast equipment. In the case of television operations the signal remains at video frequency and is viewed on a picture monitor.

Each section has a small workshop of its own where minor repairs and wiring can be carried out. A well-equipped apparatus workshop allows bigger or more precise mechanical engineering jobs to be undertaken. This workshop contains a lathe, milling machine, saw, engraving machine, electrical and acetylene welding plant, drilling machines, grinder, and bending machine. There is also a teaching workshop containing ten bench positions, grinder, bender, drilling machine, and lathe, and adjacent to the workshop a small lecture room for the students engaged on a workshop course.

14. Amenities

The original wartime dormitory accommodation, modernized in 1948, provides for 100 students and this year additional bedrooms with hot and cold running water have been built for a further 100 students. All accommodation is centrally heated. Occasionally there are women students and special accommodation is provided for them. There is a fully equipped sick bay with a nurse in full-time attendance.

A fifteen-hour daily service is available in the canteen. Provision is made for indoor and outdoor games and there is weekly ballroom dancing and alternating weekly English and Scottish country dancing. Besides an eleven-acre playing field there are about 100 acres of woodlands with walks. A warden looks after the interests of the students and arranges for their recreational activities. A large private house is maintained in Evesham as a Club where students may spend their off-duty time.

15. Conclusion

Looking back over the ten years that have elapsed since training activities were centralized at Wood Norton, the main impression is one of constant progress and development. This, perhaps, illustrates the essential difference between the work of a training department and that of an academic institution. The training department's concern is with techniques, which in the broadcasting sphere are developing from year to year, whereas additions to fundamental knowledge occur at a much slower rate. To the lecturer in a training department the pace of development provides the same stimulus and lively interest as does research to his counterpart in the academic world. The range of technical ability of the students has been wide and the great need has been to find methods of presenting information so that it makes the right impact on the less technical as well as the highly technical. This has demanded flexibility, initiative, and ingenuity from a lecturing staff to whose loyalty and enthusiasm the author wishes to pay tribute.

APPENDIX I

New Entry Courses. Syllabuses of Lectures and Practical Work. The number against each individual subject is the duration in weeks of mornings (lectures) or afternoons (practical).

1. TELEVISION TECHNICAL OPERATORS — 6 weeks

LECTURES		PRACTICAL	
Optics	1	Electricity	1
Electrical theory	1	Simple test instruments, linear and logarithmic fader controls, the oscilloscope	
Television fundamentals	0·5	Optics	1·5
Cameras and lighting	1·5	Lens, mirror, f-number, light output, simple optical instruments	
Vision equipment	1	Sound	1·5
Sound equipment	1	Aural sensitivity, velocity of sound, microphone and loudspeaker responses	
Safety precautions		Camera	1
		Operational experience on image iconoscope and image orthicon channels	
		Picture composition and lighting	1
		Safety practice	

2. TECHNICAL ASSISTANTS

Part I: All groups — 5 weeks

LECTURES		PRACTICAL	
Electrical fundamentals	1	Laboratory experiments and tutorials with exercises	2·5
A.C. theory	1·5	Circuit diagrams and workshop procedure	2·5
Valve theory and applications	2	Safety practice	
Sound	0·5		
Safety precautions			

Part II: — 7 weeks

(*a*) Transmitters Sound

LECTURES		PRACTICAL	
Radio frequency fundamentals	1	Tutorials with exercises	2
Aerials and transmission lines	1	Operational	3
R.F. power amplifiers	1	Use of cathode ray oscilloscope, simple r.f. and a.f. measurements, operation of programme input and transmitter equipment	
R.F. modulation and modulators	1	Maintenance	2
Oscillators and frequency checking	1	Simple fault tracing and correction on power supplies and transmitters	
Programme input equipment	0·5		
Power supplies	1		
Propagation	0·5		

(*b*) Transmitters Television

LECTURES		PRACTICAL	
Television and r.f. fundamentals	1	Tutorials with exercises	2
Aerials and transmission lines	1	Operational	1
R.F. power amplifiers	1	Waveform generator, vision amplifiers	
R.F. modulators	0·5	Maintenance	4
Television waveform generators	0·5	Simple fault-tracing on vision frequency apparatus, pulse generators, r.f. transmitters	
Programme input equipment	1		
Power supplies	1·5		
Monitors	0·5		

(*c*) Radio Links

LECTURES		PRACTICAL	
Television fundamentals	0·5	Tutorials with exercises	1
Aerials and s.h.f. propagation	1	Operational	3
Transmission lines and wave-guides	1	Use of cathode ray oscilloscope and simple measuring apparatus	
S.H.F. oscillators	0·5	Setting up and testing of a radio link	
Television waveform generation	0·5	Maintenance	3
Radio link equipment and power supplies	3	Simple testing and fault finding on vision amplifiers, monitors, power supplies and radio link equipment	
Monitors and receivers	0·5		

(*d*) Studios Television

LECTURES		PRACTICAL	
Televison fundamentals	0.5	Tutorials with exercises	1
Waveform generators	1	Operational Setting up image iconoscope and image orthicon channels Alignment of receiver	2·5
Vision frequency amplifiers	1		
Monitors and receivers	0·5		
Camera tubes and channels	3	Maintenance Simple testing and fault-finding on vision amplifiers, scan circuits, monitors, and power supplies	3·5
Telecine and telerecording	0·5		
Power supplies	0·5		

(*e*) Reception and Monitoring

LECTURES		PRACTICAL	
Television fundamentals	0·5	Tutorials with exercises	1
Receiving aerials	1	Operational Setting up receivers Use of simple measuring apparatus	1
Transmission lines and propagation	1·5		
Radio receivers	1.5		
High stability frequency sources	0·5	Maintenance Simple measurements on receivers Fault-tracing and correction in receivers	5
Frequency measurement	1		
Television and f.m. reception	1		

(*f*) Studio Control Rooms and Recording

LECTURES		PRACTICAL	
Test equipment and programme meters	1	Operational Setting up and operating programme chain from microphone to line output. Setting up and operating disk and magnetic tape recording channel. Setting up and operating outside broadcast equipment	5
Control room apparatus	1·5		
Studio apparatus	1		
Microphones and loudspeakers	0·5		
Disk recording and reproduction	1·5	Maintenance Elementary maintenance routine, switch contacts, valves, etc. Tests of gain and overload Interpreting control room wiring diagrams and records D.C. and A.C. testing of lines	2
Magnetic recording and reproduction	1·5		

(*g*) Lines

LECTURES		PRACTICAL	
Television fundamentals	0·5	Operational *Equalizing procedure, recognition of distortion,* setting up carrier equipment	4
The BBC communications and programme line system	1		
Equalization of lines	1	Maintenance D.C. and A.C. testing of lines, clearing simple faults in amplifiers, telegraph relay adjustment, pulse response of television circuits	3
Line testing for sound and television	2		
Sound programme equipment	1		
Television monitors	0·5		
Telegraph equipment	1		

APPENDIX II

Promotion Courses

1. TELEVISION TECHNICAL OPERATORS — 12 weeks

Part I: — 5 weeks

LECTURES		PRACTICAL	
Optics	2	Tutorials with exercises	1
Sound	1	Electricity Use of test instruments, C.R. oscilloscope, time-bases, impedance-frequency variations	1·5
Electrical and valve theory	2	Optics Transmission factor, reflectance, angle of view, directional characteristics of back projection material. Use of various types of photometer	1·5
		Sound Pressure-distance, standing waves, velocity of propagation and resonance effects	1

Part II: 7 weeks

LECTURES		PRACTICAL	
Television fundamentals	0·5	Tutorial with exercises	1
Camera equipment	2	Lighting and pictorial composition	3
Lighting and pictorial composition	2·5	Television camera work	2
Telecine and telerecording	0·5	Use of image iconoscope and image orthicon channels	
Sound	1	Sound	1
Specialist	0·5	Directional characteristics of microphones	

2. TECHNICAL ASSISTANTS FOR SOUND AND TELEVISION 12 weeks

Part I: All groups 6 weeks

LECTURES		PRACTICAL	
Basic electrical theory	1·0	Tutorials with exercises	3
A.C. theory	1·0	Laboratory experiments	3
Valve theory and applications	2	Verification of network theorems, effect of negative feedback on input and output impedance and distortion, response of simple filters, circuit tracing and fault tracing principles	
Attenuators and filters	0·5		
Measuring instruments	1		
3-Phase power circuits	0·5		

Part II 6 weeks

(*a*) **Transmitters Sound**

LECTURES		PRACTICAL	
Matching of aerials and transmission lines	1	Tutorials with exercises	2·5
R.F. power amplifier and modulator output and efficiencies	2	Operational Setting up programme input and the transmitter equipment	1
Propagation problems and aerial design	1		
Input equipment	0·5	Testing and maintenance Transmitter performance tests, distortion, noise, power output Transmission line to aerial matching for medium and short wave Fault finding on input and transmitter equipment	2·5
Power supplies	1		
Frequency stability and checking	0·5		

(*b*) **Transmitters Television**

LECTURES		PRACTICAL	
Aerial matching and combining networks	1	Tutorials with exercises	2·5
R.F. power amplifier and modulator outputs and efficiencies	1·5	Operational Setting up sound transmitter, waveform generator and vision equipment	1
Waveform generation	1		
Vision input equipment and problems	1	Testing and maintenance Stabilized power supply performance, vision frequency amplifier tests with square wave, aerial to transmission line matching, receiver alignment Fault tracing and correction	2·5
Stabilized power supplies	1		
Receivers and monitors	0·5		

(*c*) **Radio Links**

LECTURES		PRACTICAL	
S.H.F. aerials and matching	1	Tutorials with exercises	2
Waveguides and coupling circuits	1	Operational Siting and operation of link equipment	1·5
S.H.F. oscillators and modulators	1		
Link equipment	1	Testing and maintenance Tests on Klystron valve, determination of wavelength, signal/noise ratio, overall performance of link equipment Fault finding on transmitter and receiver	2·5
Waveform generation and distortion	0·5		
Vision input equipment	0·5		
S.H.F. reception problems	1		

(*d*) **Studios Television**

LECTURES		PRACTICAL	
Waveform generation and locking of separate sources	1	Tutorials with exercises	2·5
Camera tube types and performance	1	Operational Setting up camera channels and monitors	1
Camera channels and amplifier chains	2	Testing and maintenance Tests on vision frequency amplifiers, waveform generators and scanning circuits, delay lines and power supplies Fault tracing and correction	2·5
Stabilized power supplies	1		
Receivers and monitors	0·5		
Telecine and telerecording	0·5		

(*e*) **Reception and Monitoring**

LECTURES	
Receiver aerial matching	1
Propagation problems	1
Receivers for frequency measurement, quality, reception, etc.	2
R.F. measurements	0·5
Frequency measurement, principles and practice	1
Field strength measurement	0·5

PRACTICAL	
Tutorials with exercises	2
Operational	1
Alignment of receivers and use of r.f. bridges	
Testing and maintenance	3
Performance tests on sound receivers for frequencies up to v.h.f.	
Fault tracing on receivers	

(*f*) **Studio Control Rooms and Recording**

LECTURES	
Programme measuring equipment	0·5
Microphones and loudspeakers	1
Amplifiers, lines and equalization	1·5
Disk recording and reproduction	1
Magnetic tape recording and reproduction	1
Communications	0·5
Acoustics	0·5

PRACTICAL	
Tutorials with exercises	2·5
Operational	1
Studio equipment, setting up programme chain and simple equalization of lines	
Recording, setting up a disk and magnetic tape channel	
Testing and maintenance	2·5
Studio apparatus, overall tests including distortion and noise, directional response of microphones, negative feedback tests	
Recording: response tests on disk cutter heads, h.f. bias effects in magnetic tape	
Fault finding and correction in all types of studio and recording apparatus	

(*g*) **Lines**

LECTURES	
A.F. and vision frequency measuring apparatus	1·5
Lines and equalizers	1·5
Audio and vision frequency amplifiers	1
Telegraphy and telephony	1
Waveform generation and distortion	1

PRACTICAL	
Tutorials with exercises	2·5
Operational	1
Line equalization, setting up SSB transmissions	
Testing and maintenance	2·5
Tests on amplifiers, lines and equalizers	
Pulse response tests on television apparatus and lines	
Fault tracing and effect of component failure	

APPENDIX III

Graduates — 6 weeks

LECTURES	
Studio and outside broadcast techniques	1
Disk and magnetic tape recording	1
Television studio and outside broadcast techniques	2
Lines and communications	1
Sound and television transmitters	1

PRACTICAL	
Studio and outside broadcasts	1
Setting up and operating a sound programme channel including outside broadcast equipment	
Recording	1
Setting up and operating disk and magnetic tape recording and reproducing channels	
Television	2
Setting up and operating camera channels and vision studio equipment	
Lines	0·5
Testing and equalizing lines for sound and television	
Transmitters and aerials	1·5
Setting up and operating a transmitter and its aerial system	

APPENDIX IV

Studio Managers — 10 weeks

LECTURES	
Sound	1·5
Studio acoustics and artificial reverberation	1
Simple electrical theory including valves	1·5
Microphones and loudspeakers	2
Studio apparatus	1·5
Lines and transmitters	0·5
Recording systems	1·5
Specialist	0·5

PRACTICAL	
Tutorials with exercises	2
Sound	5
Velocity, wavelength, absorption, aural sensitivity, room resonances, microphone and loudspeaker responses and directional effects	
Electricity	1·5
Linear and logarithmic faders, simple amplifiers, programme effects units for bass and treble control	
Recording	1·5
Use of disk and magnetic tape recording	

APPENDIX V

Frequency Modulation — 1 week

LECTURES

V.H.F. aerials and propagation
Methods of frequency modulation
Detection of frequency modulation
F.M. service transmitter circuits

PRACTICAL

Aerials: admittance-frequency and directional characteristics of slot and dipole
Spectrum analysis and bandwidth of f.m. signal
Reactance valve characteristics
Response of amplitude, and phase discriminators and ratio detector
Amplitude limiter characteristics
Transmitter performance tests, distortion and noise

Colour Television — 1 week

LECTURES

Fundamental principles of colour
The television colour signal
Transmitting circuits
Monitoring and receiving circuits
Pictorial composition and colour harmonies

PRACTICAL

Use of spectro-photometer for determining colour components
Determining colour points of surface and transmission filters on the CIE diagram
Determination of RGB trichromatic coefficients
Setting up the optical system for the colour camera

Field Strength Measurement — 4 weeks

LECTURES

Aerials and transmission lines	1
R.F. receivers	0·5
Medium frequency propagation and field strength measurement	1·5
V.H.F. propagation and field strength measurement	1

PRACTICAL

Testing and maintenance	2
Receiver circuits for m.f. and v.h.f., fault location and correction	
Simple r.f. measurement	
Aerial admittance determination	
Operational	2
Fixed point (and moving) measurement with field strength apparatus	

APPENDIX VI

Workshop Course — 6 weeks

LECTURES: 1 week total

Benchwork tools
Interpretation of machine drawings
Principles of soldering
Principles of cutting with mechanized tools, lathe, drill, etc.
Heat treatment

PRACTICAL: 5 weeks

Tools made from following list
Benchwork: callipers (external and internal), dividers, drill angle gauge, centre and try squares, centre, pin and rivet punches
Lathework: Toolmakers' clamps, die holder, tap wrench

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