An experimental investigation of the benefit derived from the employment of specially designed equipment for instruction in fundamental electrical and radio theory

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Abstract of M.Ed. Thesis.

"An Experimental Investigation of the Benefit Derived from the Employment of Specially Designed Equipment for Instruction in Fundamental Electrical and Radio Theory".

This investigation was effected by sub-dividing a twenty weeks course in Advanced Wireless Training into fifteen Study Sections.

After securing an initial measure of ability, using the Jenkins' Test, the pupils (204) were random assigned to either experimental groups, when they had the advantage of the special training equipment, or to control groups, when they received lectures only.

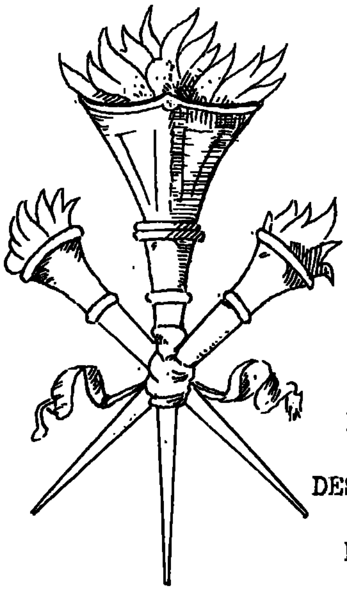
At the conclusion of each Study Section attainment was estimated by application of a suitable objective progress test.

In order to increase the precision of the investigation, the experimental groups for the first seven Study Sections became the control groups for the second seven Study Sections, the treatment of Study Section 11 was the same for both groups and the instructors taught classes using both instructional methods.

The scores obtained in the experiments were analysed by the method of co-variance when the influences of pupil and instructor variables were eliminated and the hypothesis that the difference between the two methods-groups was solely attributable to chance was examined.

In thirteen cases the results of the experimental groups were significantly superior at the 5% level to those of the control groups and in four instances these differences were outstanding at the 1% level. The Study Section, in which both groups received the same treatment, produced an insignificant value of 'F' (1.3) thereby strongly supporting the previous findings. The low value of 'F' (6.0) (F 5% - 10.14) obtained for the remaining Study Section was accepted on the basis of poorer ratio of support furnished by the practical work and it was not deemed to have established conflicting evidence.

These analyses showed that the employment of the training aids, the large majority of which were original in both design and construction, had considerably improved the standard of the training investigated.



THESIS.

AN EXPERIMENTAL INVESTIGATION OF THE BENEFIT DERIVED FROM THE EMPLOYMENT OF SPECIALLY DESIGNED EQUIPMENT FOR INSTRUCTION IN FUNDAMENTAL ELECTRICAL AND RADIO THEORY.

By Maurice E. Claxton.

"Understanding and action are so intimately related by nature that they cannot be sundered without loss - loss that does not fall least heavily on the side of understanding."

T.P.Nunn.

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CHAPTER 1.

INTRODUCTION.

A. The Aim of the Investigation.

The aim of this investigation was to assess the benefit derived from the use of specially designed demonstration and manipulation equipment employed in the training in basic electrical and radio principles of R.A.F. Signals Officers during the war years.

The experiment resulted from an attempt by the Signals School staff to replace a method of training in telecommunication engineering, that was largely didactic, by more enlightened treatment of a modified heuristic nature, which made use of radio training aids similar to those employed in civilian[1] and service[2] establishments of high repute undertaking this type of instruction.

From the psychological aspect, the investigation can be viewed as an attempt to assess the degree of transfer of training occasioned by the use of specialised apparatus. It was arranged that throughout the whole of their course in theoretical

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1. The Northampton Polytechnic, London.
2. The Telecommunications Research Establishment (R.A.F.)
2. The Military College of Science (Army)
2. H.M.S. Collingwood (Navy)

principles the experimental groups used the devised equipment while the control groups were denied these contended advantages, when a comparison between the results secured by these two groups at their various progress examinations provided a measure of the effective transfer resulting from the use of the apparatus.

Further consideration of the psychological nature of the experiment shows how the investigation demonstrated the suitability of the specialised training equipment. For a sound knowledge of radio fundamentals is entirely dependent upon a complete understanding of circuitory, which can be resolved into the behaviour of various circuit elements. The aim of the introduction of the heuristic type individual work for the experimental groups was 'to bring home the basic character of principles as a result of active work'.[3] In this way trainees were led consciously to store up 'gestalten' of the operation of different circuit elements. Thus the diagram of a valve with a low value resistor in the cathode circuit should evoke a relationship determining the mode of operation of the valve. Further if a large value capacitor is connected across the cathode resistor, the student should immediately think of Class 'A' Amplifier operation. or if the cathode resistor is unshunted, the trainee should consider the probability of amplification with negative-feedback. Again, if in a circuit

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3. Report of the Consultative Committee on Secondary Education - Mental Growth.

diagram two coupled circuits are shown, one of which is connected in the anode circuit of one valve and the other to the grid of the following stage, the student should educe from his previous experience the existence of a radio frequency or intermediate frequency amplifier stage. Further refinement of the relationship should occur for either one or both of the circuits will be variably tuned when a radio frequency stage should be educed or alternatively the tuning of each of the circuits will be pre-set, when an intermediate frequency amplifier should be recognised and, in this case, the mental process should continue and the important principle associated with tuned intermediate frequency transformers, degrees of coupling and bandpass width should suggest itself to the well-trained student.

Bearing in mind the experimental investigation which might be summarised as comparing 'learning by doing' with 'learning by hearing', the above-mentioned examples are typical of the large number of relationships which can be educed between 'fundaments'[4]. The readiness with which the bonds between the 'fundaments' are formed by a student is dependent upon his intellectual ability, the interest which he displays in his subject and the method of presentation of the 'fundaments'. In this research all the instructors at some juncture taught both experimental and control groups, when they observed the relative interest shown by

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4. 'The Principles of Cognition' Spearman.

these groups, incidentally avoiding the criticism levelled by Professor Hamley against many investigations into the transfer of training that 'there is not an adequate estimate of the interest displayed by the learner'.[5] It was found that without exception the trainees exhibited a greater degree of keenness and enthusiasm when they were completing practical exercises. It was therefore thought reasonable to anticipate that these practical exercises using the specialised equipment could be expected to produce beneficial effects. If the progress achieved by the experimental groups could be shown to be significantly superior to that of control groups, after differences due to the varying intellectual abilities of the trainees had been eliminated, the particular instructional technique advocated must have served to provide bonds between 'fundaments' which were more easily recalled and also the experiments themselves must have been suitably designed to stress these relationships, and consequently were responsible for the added interest manifested in this type of work.

B. The Purpose of the Training under Discussion.

At this stage it is appropriate to explain briefly the duties of a Signals Officer so that the type of training under discussion can be understood.

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5. Report of the Consultative Committee on Secondary Education.

The duties of an R.A.F. Signals Officer during the war years on an operational unit could be summarised as the responsibility for the operation and serviceability of all signals equipment, telecommunications and radar, both ground and airborne types used either on the unit or carried by the aircraft based on that unit. Additionally, he was responsible for the correct use of all Post Office communications facilities provided for point to point services. It therefore followed that the duties of this officer were extensive and technically onerous, but at all except highly specialised units, the complexity of the work was such that his energies were almost wholly absorbed by administration. It could consequently be stated that the primary object of the training under discussion was to produce a number of sound technical administrators. Yet, whilst this requirement was generally true, there were occasions when the Signals Officer was compelled during operational emergencies either to repair damaged equipment in order to restore channels of communication with the distant base and forward aircraft, or to set up a new station under difficult conditions and to maintain it often with no major spares and in circumstances which imposed the heaviest strain on personnel and equipment. Thus it had to be recognised, that whilst Signals Officers were generally technical administrators, under certain conditions it was imperative that they should be able to fulfil the functions of the communications engineer, fortunately this specialised employment was not normal.

C. The Trainees.

At the beginning of World War 11 optimistic advertisements seeking applicants for commissions as Signals Officers, indicated that the normal qualifications expected were either a first or second class honours degree in science, preferably electrical engineering or physics, and industrial or research experience of telecommunications. Even at the onset of hostilities candidates of this calibre were not available to the services for such men were already holding responsible appointments in industry and, in view of the expansion that was obviously necessary in commercial electronic engineering to meet wartime needs, these men were in reserved occupations and had no liability for military service, in fact, they were under the direction of the Minister of Labour and National Service and were not allowed to change their employment without the prior sanction of the Ministry.

The only class of men possessing the necessary academic background originally required was the teaching profession; and so, whilst the pulse of the nation was quickening, a large number of public spirited teachers volunteered and were accepted for duties as Signals Officers. These men, particularly those between thirty and thirty-five years of age, required little revision to recapture the entire basic electrical background; they did not have to be rehabilitated to the process of learning, they were mature thinkers not likely to make reckless decisions, and finally, they were alive with enthusiasm to tackle their duties efficiently and to defeat the enemy. This source of potential Signals Officers dried up within two years of the outbreak of hostilities and with the exception of the two year course University pupils trained under the Hankey Scheme,[6] the supply of graduates virtually ceased.

To meet the pressing need for Signals Officers which could not be satisfied by the graduate source, experienced signals tradesmen of the mechanic and operator classes were offered the opportunity to qualify. This material, judged by the initially advertised academic standard, was very mediocre but the need was imperative. The attainment of these candidates was varied, ranging from a few general degree graduates who were 'wireless-minded' and had volunteered for tradesmen's duties to service trained wireless operator airgunners, who had completed a tour of operations with distinction. Usually the latter type had barely reached matriculation standard at school probably only five years previously, but to these men it seemed so far in the remote past that the attempt to re-commence study required very hard and serious effort, and for the majority of this class the six months course was often mentally enervating, requiring fourteen hours work daily, especially at the beginning,when the time allowed for the assimilation of basic electrical principles was assessed at a revision rate.

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6. Journal of the Institution of Electrical Engineers. Vol. 94 Part 111 No. 27 - Professor Willis Jackson's Inaugural Address as Chairman of the Radio Section.

Additional disadvantages, consequent upon language difficulty, existed when Allied Nationals were under instruction. Such disadvantages were, however, often offset by the candidate's knowledge of general electrical theory, in fact, there were occasions when the language difficulty developed almost into an ~~ad~~ advantage for it stimulated such fierce discussion among the pupils that all information was analysed so frequently and so carefully that even the best instructors were particularly careful of the presentation of their subject and always sought after a greater degree of precision, for it was realised both by the instructors and the pupils that in a highly intensive course there was no time available to repeat for clarification only the contents of preceeding lectures, and yet no progress could be made without a sound conception of fundamentals.

The students involved in this experiment were non-graduate pupils of the types mentioned above, being approximately eighty per cent British and the remainder Allied Personnel.

CHAPTER 2.

THE SPECIAL TRAINING EQUIPMENT USED IN THIS EXPERIMENT.

A. Conditions Influencing the Construction of the Training Aids.

Before embarking upon a description of the special equipment used in this investigation, it is necessary to draw attention to the wartime conditions which made the task of constructing training equipment one of improvisation rather than of development. Just as civilian technical colleges and University engineering departments found that it was almost impossible to obtain new electrical apparatus other than general purpose testmeters so, during the first three war years, the service training schools suffered in the same way and were certainly less well supplied with basic electrical and radio principles training equipment. This was no reflection upon the pre-war standard of equipping these service establishments, but was due to the fact that they expanded to a greater extent and suffered greater dilution of supplies than did their civilian counterparts.

In 1943 when attempts were initiated to construct the training equipment which it was felt was required to implement the needs of the syllabus of training for Signals Officers, the service radio schools were beginning to achieve a measure of respite from these supply conditions, for limited quantities of 'salvaged aircraft equipment' were being made available. This equipment consisted of airborne radio sets, which had been recovered from damaged aircraft, apparatus which had been judged to be beyond economical repairand obsolete sets. The quantity of this material was extremely limited in 1943, but it continued to build up gradually, although it was not until 1945 that it was possible to inspect the local holdings of such material with a view to choosing the most appropriate component for a particular purpose. Prior to that time, the problem presented to the designer of training equipment was that of selecting the available component and devising suitable methods of modifying it to fulfil the desired purpose. Thus it can be claimed that considerable ingenuity and endless experimentation formed the springboard from which the early attempts were launched to construct the specialised training equipment concerned in the present investigation.

The construction of the multi-range meters used by the pupils for the measurement of valve characteristics supported the above contention. These meters were mounted on panels and were used in the determination of the constants of the commoner types of valves in use in R.A.F. sets. It was essential that they should be capable of reading up to 75 milliamperes when valves possessing high emission were being used, and yet they should be of sufficiently good sensitivity to provide an easily distinguishable change in deflection when the metered current varied by only one tenth of a milliampere over a range of ten milliamperes. The only meter which could be secured for the purpose was a two-inch scale meter having a resistance of about ten ohms and a full scale deflection of five milliamperes. It was thought desirable to provide this meter with four shunts, so that it read 0 - 15 mA, 0 - 30 mA, 0 - 50 mA and 0 - 75 mA respectively. In order to select any particular range a Yaxley type switch was employed. Using this arrangement the behaviour of the meter was most erratic. This fault was traced to variable contact resistance at the switch, a difficulty which was resolved by constructing multi-contact switches from salvaged parts.

B. Individual Manipulation Equipment.

(i) The Practice and Advantages of the 'Breadboard Scheme'.

Before describing the individual manipulation equipment in detail, the general method of construction of such apparatus was worthy of special mention. The components were mounted on a base board, usually of plywood, for lightness and strength, and all connections made by the trainees using flexible leads. Very often several different values of each component were mounted on the boards, so that the pupils could not only build different circuits on the same board, but could also study the effect of altering the values of individual components in a particular circuit. This type of manipulation panel became known in the Services as a 'breadboard'. The idea undoubtedly was not originated in the Services for similar experimental panels were utilised in pre-war days by the relatively few civilian institutions teaching practical radio circuitory. Nevertheless, this type of training aid was employed both for manipulation and demonstration to such an extent within the Service schools that the term ' breadboard' will always be associated with service training. Instructing in those technical colleges, which participated in the initial training of recruits intended to become radio mechanic tradesmen, were many civilian teachers to whom considerable credit was due for the ingenuity which they displayed in developing the 'breadboard' idea once their interest in the scheme was aroused, often as the result of a visit to a service training establishment or consequent upon discussions with R.A.F. liaison officers. Not only did the 'breadboard' scheme permit the assembly of different types of circuitory, when it afforded the trainees an opportunity of having close physical contact with various kinds of components, but it also served as an intermediate stage between the pictorial diagram drawn on the blackboard and the actual chassis-mounted set, where many of the components were difficult to find and often the inter-connecting wiring was impossible to follow.

In service radio training establishments, all of which were engaged on intensive training, it was always contended that the use of 'breadboards' made it possible to provide schemes of practical work furnishing more timely and consequently better support of theoretical principles than was the case in their civilian counterparts. This view resulted from the method of arranging laboratory exercises adopted by many technical colleges, where it was not possible to provide sufficient sets of equipment for all the students to be engaged on practical work associated with the same topic at the same time. Quite often this lack of apparatus necessitated devising a series of practical exercises in which the training course was sub-divided into sections, each of which was supported in the laboratory by a number of different experiments. In this way it was possible for students to undertake practical work consolidating a subject well in advance of the theory which they had so far learned. From a general training angle such a procedure may have certain advantages, but on short intensive courses where every effort must be made to teach a principle quickly, the 'close-support' scheme practical exercises, in which all pupils do the same work concurrently found greater favour.

(ii) Meter Equipment.

The majority of the individual manipulation panels used in this training investigation constituted a distinct departure from the previously accepted type of 'breadboard'. They could be placed in one of the following two classes:-

(a) Exhibiting originality in the equipment provided to implement the instruction, or

(b) Original in the method adopted to teach the subject.

A good example of the first class was the design and construction of the boards which afforded comprehensive facilities for individual training in meter principles, when it was attempted to consolidate instruction on voltmeter multipliers, ammeter shunts and the principle and operation of simple ohmmeters. Each of these boards contained a 0 - 5 milli-ammeter of approximately ten ohms resistance having a scale marked in twenty-five divisions. For the treatment of meter multipliers when it was intended to assemble a low reading voltmeter, a series of colour-coded carbon resistors was provided, so that any value of resistance in steps of 25 ohms up to a value of 1,000 ohms could be selected. This novel means was adopted as the normally used decade resistance boxes were not available in adequate quantities and incidentally, the method chosen, served the purpose of directing the pupils' attention to the colour code and to the tolerance rating of resistors. Unorthodox means were again employed to enable the students to increase the range of the milliammeters on the panels, adjustable shunts being made by using lengths of resistance wire stretched across the boards. The value of the shunt in circuit could be varied by loosening a set-screw and adjusting the position on the resistance wire of a moveable contact, which was in the form of a collar carrying a soldered flylead. This method was the only one that could be utilised, as suitable wattage calibrated rheostats were not available, and it had the undoubted advantage of providing a most striking illustration of the danger of open-circuiting meter shunts.

(iii) Transmitter Equipment.

The equipments designed for teaching transmitter and receiver principles were typical of the second class of 'breadboards' specially constructed for the training of Signals Officers. Each set of apparatus used for instruction in transmitter theory consisted of four 'breadboards', on which the students could 'wire-up' several types of transmitters. On the first of these panels any one of eight common oscillators could be assembled using a triode or pentode valve. The second board provided the means of constructing the second stage of a transmitter, which could employ either a neutralised triode or a pentode valve. In order to cater for the possible choice of telephony or telegraphy this panel contained additional components, so that the power amplifier stage could be either grid modulated or keyed. The output from the final stage of the transmitter was fed to a third board on which was a tunable dummy load, which could be capacitively or variably link-coupled to the anode circuit of the power amplifier. If it had been desired to assemble an anode modulated transmitter, the fourth board provided facilities for constructing a two stage audio frequency amplifier, with which either a carbon or an electro-magnetic microphone could be used. An important advantage attendant upon the use of these transmitter boards was that one of the transmitters assembled and operated by the trainees had a circuit almost identical with that of the then current airborne general purpose transmitter and consequently, the exercise consolidated knowledge of basic principles as well as serving as a means of affording familiarity with typical radio components, and further constituted an excellent introduction to an important item of equipment which was to be studied in detail later in the course.

(iv) Receiver Equipment.

The receiver manipulation boards were as comprehensive as the transmitter boards in the range of circuits for which they afforded facilities for construction, and like the transmitter panels they followed the same practice, each board providing the means to assemble a certain type of receiver stage. In this way sufficient kinds of panels were available so that the pupils were initially directed to 'wire-up' a simple one valve receiver, and ultimately to construct a six-stage superheterodyne, complete with tuning indicator. In order to stimulate interest, two sets of tuning coils were provided for all these training equipments, so that either the medium wavelength or the long wavelength programme of the British Broadcasting Corporation could be received. In certain instances, it was found possible to retain the assembled transmitter boards until the trainees undertook receiver constructipn exercises, When the quicker students had an opportunity of using both sets of panels for point-to-point communication, starting with single channel working and progressing to twin channel operating. This type of practical work rarely failed to arouse the enthusiasm of the pupils, and it had the advantage of giving a very practical bias to exercises primarily intended to consolidate theoretical principles.

(v) Alternating Current Equipment.

The design of the equipment provided for individual instruction in the alternating current laboratory furnished another illustration of the improvisation necessitated by wartime conditions. This apparatus, in common with that previously described, was entirely manufactured in the school workshop. It overcame the impossibility of acquiring twelve audio frequency generators, which were needed to implement the accepted policy of the school in arranging that students undertook their laboratory exercises simultaneously. The equipment consisted of two main parts:-

(a) An obsolete transmitter modified to operate from a mains power pack and tuned to give an output of a few watts at the fixed frequency of 300 Kc/s., which was fed via a correctly terminated low impedance transmission line to distribution points on the pupils' benches.

(b) Twelve mixer units which were operated by the trainees.

The mixer units consisted of a triode hexode valve followed by an audio frequency amplifier. The signal grid of the frequency changer valve was fed from the transmission line and the oscillator section of the valve was tunable over a range of 290 Kc/s. to 300 Kc/s. The output stage was preceded by a gain control and equipped with a high resistance A.C. voltmeter, thus the pupils were provided with sources of audio power whose frequency and amplitude were under their control. Two different sets of 'breadboards' were employed with this equipment. The first type mounted an air-cored inductance of approximately 0.1 Henry, which was accurately tapped at quarter and half value points; four 0.1 microfarad capacitors and a 0 - 500 microammeter suitably shunted and equipped with a locally assembled rectifier unit so that it read 0 - 5 milliamperes A.C. The second type of manipulation panel was similarly provided, but housed two sets of capacitors and two inductors, the latter being mounted on a horizontal axis so that their relative positions could be varied at will. Using this equipment the trainees were able to complete with considerable satisfaction a series of simple A.C. exercises, which consolidated the fundamental principles essential for their radio training.

At this point it is thought apt to comment upon this method adopted to provide variable frequency power for the A.C. experiments. From the electrical point of view this novel procedure, which was first used at the R.A.F. Training School established temporarily in the Natural Science Museum at South Kensington, and later at the Birmingham Technical College, where it received favourable commendation from Inspectors of the Ministry of Education, functioned successfully so long as it was arranged that the transmitter operated under low power conditions, and that the loading on the transmitter and power units was not subject to large fluctuations. The first of these points was satisfied by arranging that the power required from the transmitter did not exceed one tenth of its rated output, and the second condition was fulfilled by making sure that the full number of mixer units was always used. From the teaching aspect, this method proved sound for it provided quantitative variations whose precision more than amply satisfied the demands of the training but for more advanced study, such as, University final degree electronics course, where more accurate frequency calibration would be demanded, the equipment used in this investigation, although cheap to construct, would not be adequate.

(vi) Aerial Equipment.

One of the important advantages always claimed for the training under review was the benefit derived from the aerial and transmission line experiments available in the school's aerial laboratory, one of the few such training laboratories in this country. The main difficulty encountered in preparing these experiments was that of providing sources of suitable power and frequency. This problem was resolved by utilising obsolete airborne radar transmitters, modifying them to operate at a higher frequency of the order of 300 Mc/s. and arranging that both the filaments and the anodes of the valves were fed with A.C. power.

Unfortunately, the majority of these experiments had to be designed to operate at frequencies in the neighbourhood of 300 Mc/s. in order to keep the size of the equipment within suitable limits. Consequent upon this choice of frequency, it was found that such a degree of coupling occurred between the different experiments that it was impossible to operate more than one at a time, and as a result it had to be decided to demonstrate this series of experiments.

(vii) Laboratory Power Supplies.

One of the chief considerations which had to be weighed carefully when designing equipment for manipulation and demonstration purposes was the number of man-hours required for the preparation and maintenance of the apparatus. In certain laboratories where the 'loading' justified a full-time technician for maintenance purposes, it was found of great advantage if this man could spend as large a proportion as possible of his time assisting the theory lecturer in checking exercises and helping the pupils. The greater the number of man-hours required for maintenance, the smaller the proportion of the staff that could be made available for this purpose. It therefore followed that if the instruction in theoretical principles was to be supported by a wide range of practical exercises and demonstrations, it was essential that these equipments should be robust in construction, reliable in operation and that the supply of power for their operation should not necessitate the never-ending problem of accumulator replacement and charging. Whilst the success with which the first two conditions was met, was largely dependent upon the skill of the designer of the apparatus and the attention paid to detail by the constructor, the third condition was satisfied by eliminating the use of wet and dry batteries, where possible, from the laboratories and substituting either mains operated power packs or the direct provision from the mains of the required power. The latter procedure, as carried out in the valve laboratory, constituted a definite departure from the normal practice in supplying power for such work when either dry high-tension batteries or potentiometers across the D.C. mains were utilised. The practice adopted, consisted in trickle-charging fourteen twelve-volt accumulators in series from the D.C. mains. The terminations of each of these batteries were led via a set of primary fuses through a fifteen-core cable to concealed sockets in distribution boxes on the pupils' benches. Each of the sockets was labelled with its nominal voltage as the accumulators were on charge, but the true voltage on a particular line could always be measured by the pupils by switching any one of the three monitor meters to the line in question. These distribution boxes provided the high tension supplies necessary for the determination of valve characteristics, whilst bias voltages were catered for by a similar arrangement, using twelve two-volt accumulators trickle-charged from the A.C. mains, and the valve filament or heater supply was obtained from locally manufactured transformers giving an output of 4.0 volts, 6.3 volts or 13.0 volts. Such supplies required little maintenance other than periodic 'topping-up' of the accumulators whose output was immediately available. As so far described this installation suffered from a serious defect, for any student by faulty connection could short-circuit the supplies to the whole class. This potential danger was guarded against by the inclusion of secondary fuse boxes in the circuits assembled by each of the trainees.

C. Demonstration Apparatus.

The description of the training aids used in this investigation would not be complete without reference to the apparatus employed for lecture demonstration purposes, Much of this apparatus followed traditionally accepted patterns but, in many instances, novel features were added. Whilst it is thought neither appropriate nor desirable to describe in detail all the purely demonstrational equipments, it is considered relevant to attempt to convey a general impression of these devices by supplying particulars of the construction and uses of three typical aids.

(i) Eddy Current Damping Demonstration.

A large electro-magnet, as shown in the accompanying photograph, was wound with ample turns of number 18 gauge double cotton-covered copper wire so that when it was connected to the standard laboratory twenty-four volt set of heavy duty accumulators, whose output could be boasted by charging them from a rectifier, an intense field was generated between the pole-pieces. An auxiliary support carried a weight-driven motor equipped with an over-run mechanism. The main spindle of this motor drove an auxiliary shaft to which could be attached speedily either a plain disc or one with a large number of radial slots. These two discs were mounted so that they could rotate between the poles of the magnet and the phenomenon of eddy current damping shown by completing the energising circuit. This demonstration owed its success to the operation of the over-run mechanism, which permitted several successive demonstrations to be given of the effect, without re-winding the motor and thereby attracting the interest of the pupils by the observation of details secondary to the main purpose of the demonstration.

(ii) Radio Circuit Demonstration Panels.

For the demonstration of the operation of particular circuits, a large diagram of the circuit was outlined in black upon a lightly stained plywood board, often the side of a packing case, which was furnished with legs so that it could be stood in an almost vertical position on the demonstration bench in front of the class. In positions corresponding to their symbols shown in the circuit diagram the components used were mounted behind the panel.

Such a demonstration board merely required connection to a variable voltage mains operated power pack or to the bench low tension supply when it was immediately available for teaching purposes. When the operation of the circuit being studied could best be accomplished by viewing waveforms, a cathode ray oscilloscope was employed and, if necessary, a cathode follower unit was built-in behind the panel so that the shunting effect of the indicator unit did not mar the performance of the circuit. Such demonstrations served as excellent teaching aids but at the time of the investigation, when the size of the 'picture' was limited to a diameter of six inches, inconvenience and loss of time resulted from the need for arranging that the class viewed the demonstration in sections.

(iii) Valve Characteristic Demonstrations.

One of the most interesting demonstrations utilising probably the most complicated locally constructed equipment was that of valve characteristics shown on an oscilloscope. The valve testing equipment employed followed the well-established technique for cathode ray tube purposes, but it was complicated by reason of the multiplicity of facilities it offered, permitting the showing of mutual or anode characteristics of all the common types of Service valves. This instrument was normally used in the valve laboratory immediately after the pupils had plotted characteristics or in the class-room for contrasting types of valves and for revision purposes. Of all the uses to which it was applied it was always agreed by the staff and trainees that the most vivid demonstration was that of the influence of the suppressor grid in a radio frequency pentode. By the action of the appropriate selector switches the suppressor grid of such a valve could be connected to the screen and then to the cathode. The difference between the two anode characteristics was clearly seen by comparing the accompanying photographs of the oscillograms obtained. The demonstration was rendered so realistic by switching from tetrode to pentode operation at will and the degree of assimilation of the phenomenon by the students was so high that the success of the equipment more than compensated for the time and effort devoted to its construction.

CHAPTER 3.

ORGANISATION OF THE EXPERIMENTAL PROCEDURE.

In evolving a suitable organisation for this experiment it was essential that no changes were introduced whereby any of the trainees were debarred from the advantages that might have attended the employment of any of the training aids, otherwise those students who were not permitted the use of the devices might reasonably have urged that their progress was impeded. Any criticism of this nature would have resulted in the termination of the experiment. It was therefore important to ensure that by the conclusion of the course all pupils had received the same lectures, had seen the associated demonstrations and had carried out the same practical exercises, had in fact, undertaken the same study content. It was, nevertheless, necessary to arrange that there were two distinct methods of instruction, one with the aid of the specially designed demonstrations and individual practical work and the other without these aids, so that their training value could be assessed.

Reference to Appendix A, giving the teaching content of the course, and to the following details of the organisation for the two methods, shows that it was possible to divide the syllabus content into fifteen study sections, which will be called S_1 to S_{15}. Each study section was sub-divided into a lecture content L and an associated practical work content P. The suffixes allocated to these two letters indicate the study sections upon which they were based.

In method 1, in the treatment of the study sections 1 to 7, in each case the lectures were delivered, supported by the use of the specially designed demonstration equipment and consolidated by allowing the pupils adequate opportunity to carry out the associated individual practical exercises. At the conclusion of the work of each of these seven study sections, the acquisition of knowledge by the students was tested by the application of progress tests, specially designed for the purpose. For the remainder of the course, with the exception of the scheme for study section 11, the pupils were given lectures without supporting practical work and progress tests were applied at the conclusion of each section. The pupils did not lose their practical work. It was given in each of the seven remaining sections immediately after the progress test, as shown in the table below. The progress test appropriate to each of these seven sections was intended to be re-applied after the practical work relating to its section had been covered.

In method 2, the above treatment was reversed. The contents of each of the study sections 1 to 7 were taught without the aid of the special teaching equipment and the same progress tests as applied under method 1 were given at the conclusion of each section. This was identically the same procedure as that adopted for the second half of method 1. For the second half of method 2, the sequence was lectures concurrent with the associated practical work, progress at the end of each stage being assessed by the use of the same tests as employed for method 1. Thus it is seen that the second half of method 2 was conducted on lines identical with the first half of method 1.

A comparison between the two methods is best understood by reference to the outline chart shown below or by the study of Appendices B and C, which give full details of the organisation for each method.

OUTLINE CHART.

STUDY SECTION NUMBER	METHOD 1			METHOD 2		
	Lectures	Practical Work	Tests	Lectures	Practical Work	Tests
1.	L_1	P_1	T_1	L_1	Nil	T_1
2.	L_2	P_2	T_2	L_2	P_1	T_2 & T_1
3.	L_3	P_3	T_3	L_3	P_2	T_3 & T_2
4.	L_4	P_4	T_4	L_4	P_3	T_4 & T_3
5.	L_5	P_5	T_5	L_5	P_4	T_5 & T_4
6.	L_6	P_6	T_6	L_6	P_5	T_6 & T_5
7.	L_7	P_7	T_7	L_7	P_6	T_7 & T_6
					P_7	T_7
8.	L_8	Nil	T_8	L_8	P_8	T_8
9.	L_9	P_8	T_9 & T_8	L_9	P_9	T_9
10.	L_{10}	P_9	T_{10}& T_9	L_{10}	P_{10}	T_{10}
11.	L_{11}	P_{11}& P_{10}	T_{11}& T_{10}	L_{11}	P_{11}	T_{11}
12.	L_{12}	Nil	T_{12}	L_{12}	P_{12}	T_{12}
13.	L_{13}	P_{12}	T_{13}& T_{12}	L_{13}	P_{13}	T_{13}
14.	L_{14}	P_{13}	T_{14}& T_{13}	L_{14}	P_{14}	T_{14}
15.	L_{15}	P_{14}	T_{15}& T_{14}	L_{15}	P_{15}	T_{15}
		P_{15}	T_{15}			

Reference to the foregoing chart shows that if two groups, each taught by the same instructor, study by Method 1 and Method 2 respectively, then for the treatment of the first seven sections the first is the experimental group and the second the control group. For the other sections, except section 11, the roles of the two groups are reversed.

Section 11 contained instruction on two transmitters, which were included in the syllabus as typical medium power ground-station transmitters, as their study was judged most suitable to consolidate the pupils' knowledge of contemporary techniques. These transmitters were, at the time of the experiment, ground-station transmitters in current use, hence it was essential that the pupils should not only be taught their circuitory and action but also learn their tuning and control. It would have been ridiculous to have attempted to divorce the theory from the operation of these equipments, and whilst it might on some other occasion be desirable to vary the relative times devoted to circuitory and manipulation so as to assess the optimum time for each, it would have been unthinkable to reduce the associated practical work in this case to zero. It was therefore considered the best policy not to attempt any subsidiary investigation but to adhere simply to the purpose of the experiment and to teach the circuit and practical manipulation of these equipments in precisely the same way under both methods.

CHAPTER 4.

ORGANISATION OF THE STUDY GROUPS.

The intakes of trainees at the Officers' School were normally single classes, each approximately twenty strong, with an entry rate at the time of the experiment, ranging from one every four weeks to one every seven weeks. The School was organised so that one officer instructor undertook the whole of the teaching in basic electrical and radio principles to a particular class.

It was therefore decided that the class must be the unit of organisation and consequently classes became study groups. As will be seen later from the method of analysis adopted it was important for :-

(i) All the teachers involved in this experiment to have instructed groups by both methods and that the groups were of equal strength.

(ii) The teachers to have been assigned to the different methods by random selection.

The first condition, as is shown by the table set out below, was not fulfilled in practice and it became necessary to adjust the results obtained to the form of the analysis.

Instructor	No. of Classes		No. of Pupils	
	Method 1.	Method 2.	Method 1.	Method 2.
1	3	2	56	36
m	1	1	19	20
n	1	1	16	18
o	1	1	18	21
p	1	1	17	13
Totals 5	7	6	126	108

Confining attention to the pupils' results obtained under Method 1, it was necessary to choose 36 out of the 56 taught by instructor '1' and 13 out of the 17 taught by the instructor 'p'. Similarly referring to the pupils' results secured under Method 2, it was required to select 19 out of the 20 pupils taught by the instructor 'm', 16 out of the 18 taught by the instructor 'n' and 18 out of the 21 students taught by the instructor 'o'.

In order to carry out this selection, use was made of the table of random numbers included in the Statistical Tables for Biological, Agricultural and Medical Research devised by R.A.Fisher and F.Yates. Since the table was constructed on the principle that any digit 0 to 9 had an equal chance to appear in any given position in the table, a random choice of starting point was made and reading down the column chosen numbers were read off until 36 different ones each less than 56 were obtained.

In practice it was found necessary to employ the column originally chosen and, in addition, the next two consecutive columns before all the numbers required were obtained. Then as each of the 56 pupils had to be numbered from 00 to 55, use of the selected random numbers indicated which of the pupils' results to employ for the purpose of the experiment.

The same procedure was adopted to complete the selection of the other pupils' results as shown below:-

	Instructor	Method 1.	Method 2.	Totals
	l	36	36	72
	m	19	19	38
	n	16	16	32
	o	18	18	36
	p	13	13	26
Totals	5	102	102	204

In order to satisfy the condition that the instructors should be assigned by random selection to the different methods, and since classes on arrival in the School were allocated to the various instructors, only one of whom was normally available at the time, it followed that the study groups were random assigned to methods. It was decided prior to the commencement of the experiment to draw up tables for the five instructors indicating the methods by which their first six classes were to be taught. These tables, which are shown below, were obtained by selecting at hazard any point in the table of random numbers. The number indicated and the five below it in the same column were observed. Even numbers were taken to signify Method 2 and odd numbers Method 1, the predictions being as below:-

Instructor	Method to be used.					
	1.	2.	3.	4.	5.	6.
l	2	2	1	1	1	2
m	1	2	1	1	1	2
n	2	1	1	2	2	2
o	2	1	1	1	2	1
p	1	2	2	1	2	2

CHAPTER 5.

THE TESTS EMPLOYED IN THE INVESTIGATION.

A. The Initial Criterion Test.

(i) The Choice of the Test.

It was necessary in this investigation to have a valid measure of the abilities of the trainees at the commencement of the course.

The choice of the test for this purpose was limited, for it had to be remembered that the pupils might sometimes be Allied Nationals, consequently it was imperative that there was no dependence on vocabulary. The tests finally considered were the Non-Verbal Mental Ability Tests due to Dr. Jenkins and the Matrices Tests designed by Mr. Raven. Both these tests had the advantage of being based upon a principle - the perceptual recognition of printed elements - which might well be, if not essential, certainly of first rate importance in the acquisition of the knowledge of radio circuitory.

The Jenkins' Tests were finally chosen as they were considerably cheaper to purchase and, in addition, the number of separate problems (85) was greater than in the Raven Tests (60(from which it was thought probable that a wider range of results would be secured, and in consequence a finer grading of pupils' abilities realised.

(ii) The Application of the Test.

In applying these tests several small departures were made from the instructions provided by their originator, but none of them, it is claimed, was sufficient to cause any invalidation of the results obtained.

In the first place, twenty-five copies of the Test were purchased, and it was decided to use these as standard copies to be issued in turn to all the classes of students. The five possible printed solutions to each of the eighty-five problems were labelled in each case (a), (b), (c), (d) and (e). An answer pro forma, as shown at Appendix D, required the testees to cross out the four incorrect solutions, thus facilitating marking with the aid of a stencil.

These tests were administered by a member of the School Staff, who adopted the following procedure :-

(a) Ensured that at the time appointed for the group testing, the class-room was well heated and that a clock was clearly visible to all testees, who were questioned to ascertain that they had either pen or pencil.

(b) Distributed five copies of the answer pro forma to each member of the class.

(c) Explained that it was the policy of the School to assess the abilities of all students before they started the course and that, with this object in view, all pupils were required to supply answers to the Jenkins' Tests.

(d) Distributed copies of the Jenkins' Tests: directed attention to the printed instructions on the outer cover. Explained additionally that this exerwise consisted of five separate tests for each of which ten minutes and no more would be allowed.

(e) Directed the trainees to write their names and course number on each of the answer sheets and to label these sheets, Test 1, Test 2, Test 3, Test 4 and Test 5, respectively, so that they were all prepared to start when told.

(f) Instructed the pupils to select the answer sheet labelled Test 1. Re-directed their attention to the bottom of the front page of the Test Booklet.

(g) Gave the signal to start.

(h) After ten minutes stopped the pupils and directed them to commence answering Test 2.

(i) Repeated the above procedure until all five tests were completed.

(j) Collected answer sheets and test booklets.

There were no instances of testees using an incorrect procedure in answering these questions.

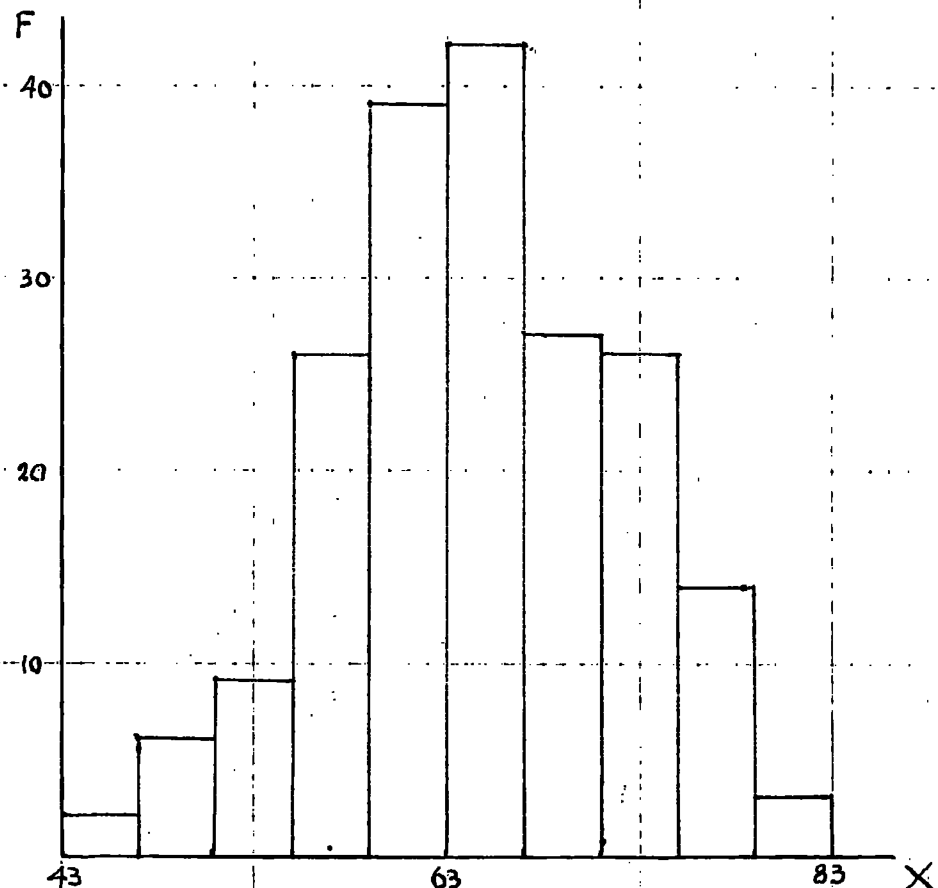
(iii) The Normality of the Results of the Jenkins' Tests.

In order to determine whether the results obtained from this investigation could be considered typical of the general population of pupils selected for this particular type of training, it was thought desirable to check the normality of the

HISTOGRAM

OF

DISTRIBUTION OF INITIAL TEST SCORES.



JENKINS' TEST SCORES.

distribution of the Jenkins' Test scores secured by the students constituting the sample of 204 cases considered in this investigation.

A histogram giving the general form of the distribution of the scores obtained is shown. Fuller details indicating how the normality of the results was calculated are included in Appendix E.

The scores were arranged in twenty different classes. The mean and the standard deviation of the tabulation were calculated. Then using probability integral tables, a normal distribution of 204 cases, having the same mean and standard deviation, was constructed. The difference in frequency distribution between the observed and the calculated normal tabulation was determined using the 'Chi-squared method'. The value of 'Chi-squared' thus obtained was 18.508. About 40% of all random chosen samples would be expected to yield a value of 'Chi-squared' of 18.508 or greater. Hence, it was deemed not unreasonable to accept the sample considered as a normal one. Since it must be accepted that the entire population of trainees was normally distributed, it was concluded that the sample under investigation was truly representative of the population under discussion and that any conclusions derived from this investigation were equally applicable to the whole population of trainees. The degree of reliability of the conclusions reached, as a result of this experiment, was similar to that which would have been secured had it been possible to select at random from the total number of trainees, certain pupils, and measure their reactions to the type of training under consideration.

B. The Progress Tests.

(i) The Preparation of the Tests.

In order to assess the relative progress of both experimental and control groups, objective tests, termed progress tests, were applied at the completion of each of the fifteen study sections of the course.

After considerable discussion and no small amount of disagreement, it was accepted by the School Staff, that valid progress tests could be devised containing questions either of the multi-choice answer type or of the true-false variety. Opposition existed, for it was contended by several of the more experienced members of the Staff, that questions of such types could only be prepared to test superficial knowledge of a complicated science, but in view of the fact that the results secured would not prejudice the pupils' chances in the final examination, their co-operation and assistance was finally obtained.

The first stage in the construction of these tests was to ask ten experienced instructors to prepare sets of twenty objective questions to cover the syllabus content of each of the fifteen study sections of the course. These instructors were advised to examine the syllabus and decide which were, in their opinion, the twenty most important points. The questions were then to be framed about these topics.

The sets of questions thus compiled were examined by a committee of four, who selected from the two hundred available questions, twenty, judged the most appropriate to test the knowledge of each section. This final selection constituted the progress tests shown at Appendix F.

(ii) Application of the Tests.

To assist in the application of these tests an answer pro forma was prepared which could be rapidly marked using a stencil. (See Appendix G.)

The instructions printed at the top of each answer sheet clearly indicated the manner in which the questions were to be answered and the method by which the results would be assessed was stated on each sheet :-

Marks will be allotted as follows :-

One mark for each correct answer.

One mark deducted for each incorrect answer.

Thus do not guess or you will be penalised.

When these questions were first formulated, it was thought possible, especially where the 'true-false' type was employed, that many trainees might be tempted to gain marks by speculation rather than as a result of acquired knowledge. However, an examination of the results of the first two progress tests, taken by all the students participating in this investigation, showed that the percentage of incorrect to correct answers was on the average only 8.96% - ranging from 15.15% to 4.91% - as shown in

Appendix H. It was therefore concluded that the instructions had the desired effect of restraining testees from guessing. Consequently, as it was impossible to decide between a genuinely incorrect answer and a wrong forecast, it was agreed not to deduct marks for incorrect solutions. Nevertheless, it was deemed advisable not to amend the instructions and so ensure that the conditions of the test were not varied.

(iii) Results Obtained.

These results are shown in detail at 'Appendix I' .

CHAPTER 6.

THE METHOD OF ANALYSIS EMPLOYED.

A. Advantages Achieved.

The experimental results obtained were analysed by the method of co-variance developed by R.A.Fisher and as expounded by Professor E.F.Lindquist.*

This procedure offers several important advantages over other methods. Any experiment designed to compare the relative efficiencies of different treatments must take into account the pupil variable. It can be assumed that pupils, provided a large number is involved, constitute a normal sample and that the various experimental groups required by the design of a methods-experiment, such as the present one, may be assembled by random assignment of the pupils. The groups thus selected may reasonably be accepted as 'equated samples'.

Alternatively an initial attainment test, usually seeking to measure knowledge of the subject concerned in the investigation, is applied. Using the scores secured in this test, the students are then graded into several different categories, from which random selection is made so that 'matched groups' are assembled.

Both these methods of assembling study groups have the disadvantage of involving considerable pupil reorganisation, invariably disrupting the school in which the experiment is being

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* 'Statistical Analysis in Educational Research' by E.F.Lindquist.

carried out. It is possible to avoid this disorganisation in the following way. Having applied an initial criterion test, the pupils are subjected to the different treatments being investigated, using their normal class organisation. Finally, all the pupils in these classes answer the same achievement test at the completion of the various methods of treatment. Reference is then made to the initial criterion test scores, and lists of names are compiled so that 'matched samples' are considered as existing in each of the class treatment-groups. The final achievement marks are then scrutinised and all discarded, except those of the pupils constituting the matched groups. In this way much valuable information is lost.

Analysis by co-variance does not necessitate any class reorganisation and no information is discarded. Initial criterion and final achievement tests constitute the only data required. In general terms this method investigates the hypothesis that the study groups are all part of the same pupil population. Allowances for initial differences of attainment between individual cases is made in terms of the regression of the final achievement test upon the initial criterion test scores. An adjusted set of final scores for the study groups is determined, such that differences due to initial inequalities are removed. If the residual differences between the adjusted final group scores are greater than can be accepted as due to random selection, then the hypothesis that the groups are part of the same pupil population is untenable, and consequently, there must be a significant difference in effectiveness between the treatments studied.

B. Adaptation of the Analysis to the Form of the Experiment.

The investigation described in this paper was sub-divided into fifteen different sections, at the conclusion of each, the achievement test employed was the appropriate progress test. In this way the investigation became a series of fifteen successive experiments.

At the commencement of the course the Jenkins' Test was applied and, as has been previously explained, before the students received instruction on the next section of the syllabus they all had been given the same total theory and practical work, although the sequence was different for the Control Groups and the Experimental Groups. Consequently, it was deemed the best policy to use the original Jenkins' Test scores as the initial measure for each of the fifteen experiments.

The validity of this procedure was checked by selecting five classes and arranging for their members to be re-tested with Jenkins' Test after varying intervals. A minimum period of twelve weeks was permitted between the original test and its repeated application, so as to avoid as far as possible, bias of the re-test results due to memory of the first test.

No. in Class	Instructor Group to which testees belonged.	Period between initial test and re-test. (weeks)	Correlation Coefficient. Original and re-test scores.
19	l_1	17	.86
19	m_2	21	.96
16	n_1	15	.95
13	p_1	12	.95
13	p_2	19	.96

The results shown above very clearly justify the procedure adopted. The complete detail of these results is included at Appendix J.

The possible alternatives to the procedure employed were :-

(a) To use the series of achievement test scores obtained at the conclusion of one experiment as the initial criterion measure for the next experiment. Such a practice was thought reasonably sound for the experimental groups, where the theory and associated practical work were undertaken concurrently, but not applicable directly to the control groups, whose members were tested before they had undertaken the scheme of practical exercises supporting the theory of each study section under review. An attempt to overcome this difficulty would have been to submit the members of the control groups to a second application of the appropriate progress test. These re-tested results were considered, as shown later, to be of very doubtful value as a measure of acquisition of knowledge.

Any increase in the re-test score over the first test score might well be due to memory of the original test and not as a result of any additional instruction.

(b) To have devised a new test or used a different accepted type test as the initial criterion measure for each of the fifteen experiments.

As far as accepted type tests were concerned, the only suitable tests were the Jenkins' Test and the Raven's Tests, so that this courde was highly impracticable. In addition, it was felt that no two different ability or attainment tests could be relied upon to test precisely the same sphere of knowledge. Thus, whilst a different initial criterion test could be employed for each experiment, the use of such different tests was not helpful, when the final conclusion of the investigation depended on agreement between the various experiments.

New tests on the same objective lines as the progress tests could have been devised, but such tests would have lacked the validity of the accepted type tests, and what was probably most important, time could not have been made available for the application of such tests.

CHAPTER 7.

THE FINAL EXPERIMENTAL RESULTS.

A. Summary of the Results.

The analyses of the scores secured in the fifteen experiments, as typified by the solution of those obtained in Study Section 1, shown at Appendix K, produced the results given below :-

(Seven figure logarithms used).

Study Section	1	2	3	4	5	6	7
S. of s. for Methods	96.0	220.3	186.4	185.6	250.3	157.1	107.3
S.of s. for Methods x Instructors	47.3	56.0	41.3	35.6	21.2	37.0	29.2
S. of p. for Methods	-15.5	-22.7	-20.8	-28.0	-23.8	-19.2	-16.1
S. of p. for Methods x Instructors	-18.0	87.9	60.3	64.4	51.2	-64.4	-40.0
Adjusted Methods Variance	92.8	236.0	195.7	198.2	258.6	144.8	100.6
Adjusted Error Variance (Adjusted Methods x Instructors)	15.4	7.2	8.4	5.7	3.2	6.2	7.4
Methods diff. 'F' value.	6.0	32.6	23.3	34.7	80.8	23.9	13.7

Study Section	8	9	10	11	12	13	14	15
S.of s. for Methods	190.3	130.3	143.5	6.5	123.9	119.2	99.0	98.3
S. of s. for methods x Instructors	43.7	20.8	18.5	15.3	30.8	11.6	27.7	13.5
S.of p. for Methods	23.4	16.4	17.9	3.1	15.7	15.3	13.8	19.0
S. of p. for Methods x Instructors	18.7	23.5	-33.4	10.5	4.5	-3.0	3.5	4.0
Adjusted Methods Variance	184.1	144.1	147.5	6.2	122.1	118.9	97.7	96.0
Adjusted Error Variance (Adjusted Methods x Instructors)	14.0	6.1	4.5	4.9	10.3	3.9	9.2	4.5
Methods diff. 'F' value.	13.1	23.5	32.7	1.3	11.9	30.4	10.6	21.4

Minimum value of 'F' for significance 1% and 5% levels

34.1 and 10.1 respectively.

Observation of the above results shows that in thirteen cases out of fifteen there is a difference significant at the 5% level in the effectiveness of the two training methods investigated. In four cases this difference is apparent at the 1% level of confidence, and in one case it is exceptionally significant even at that level (F - 80.8).

B. The Apparently Anomalous Cases.

It is interesting to consider the two sets of results which failed to yield differences not significant at the 5% level.

(a) One of these was that obtained from Study Section 11, where it had been decided originally to employ the same treatment for both groups, as the content of the Section did not permit of any time separation between lectures and the pupils' associated practical work. In this case, it was therefore only to be expected that no significant difference would be shown, a conclusion happily supported in practice by the low value of 'F' obtained (1.3).

(b) The second set of somewhat anomalous results was derived from Section 1 of the investigation. A value of 'F' of 6.0 being secured, whilst significance at the 5% level would be indicated by a value of 10.14 or more. The value of 'F' obtained is therefore considered not large enough to support the contention that there is a difference in effectiveness of the two treatments, but it is nevertheless sufficiently large not to be dismissed without further thought.

In the view of the investigator, since experiment 1 is the only one of fifteen experiments, which yielded a strictly anomalous result; this lack of agreement is probably due to faulty design of the experiment. It is possible that the practical work devised was not suitable to assist the assimilation of the theory content, in which case, the achievement test questions could have been answered equally well, whether or not the supposed supporting practical exercises had been undertaken. That the practical work in this section only was wholly unsuitable to support the theory was highly improbable, for quite a number of people of experience had approved it. Nevertheless, it is possible that the degree of support afforded by the practical work was lower for this section than for the others. This suggestion was not lacking in support, if the syllabus of Study Section 1, was compared with those of the other sections. In Section 1, excluding the one period made available for an introductory lecture, the purpose of which was to explain the object of the course, only eight hours were allowed in which to impart a knowledge of the Constitution of Matter, Magnetism and Current Electricity to at least School Certificate standard. It was consequently obviously impossible for an instructor to adopt any other course in the time available, than to revise the more important parts of this section of the syllabus and to attempt to solve individual problems. The practical work associated with this Section, for which only four hours was allocated, involved exercises, which without doubt supported some of the main features of the theory content, but it did not provide as extensive a ratio of support as given in the other Study Sections, where the range of theory was much smaller.

e.g. Section 2. Primary and Secondary Batteries and Induction - 11 hours theory with 7 hours supporting practical work.

C. Comparison between the Results obtained in the two Phases of the Course.

Notwithstanding the results of the above-mentioned two experiments, the general trend of the investigation is thought to be highly convincing, a fact strikingly substantiated when it is remembered that the experimental groups of the first seven sections became the control groups of the last seven sections. Recalling that the type of treatment for Section 11 was common, it was of interest to compare the 'F' values secured from the first seven experiments with those obtained from the last seven experiments - excluding Section 11.

Expt. No.	1	2	3	4	5	6	7
'F' value	6.0	32.6	23.3	34.7	80.8	23.9	13.7
Expt. No.	8	9	10	12	13	14	15
'F' value	13.1	23.5	32.7	11.9	30.4	10.6	21.4

The former gave an average value of 'F' - 30.7 against 20.5 obtained as the mean value in the last seven experiments. Thus, although those groups which received lectures and supporting practical work concurrently yielded achievement test scores, showing a significant superiority over the results obtained by the other groups, this difference was less marked in the case of the last seven experiments, i.e. after the group change-over, although in all cases it was significant at the 5% level. As the course was progressive, the knowledge gained in one section formed the background on which to build the next section. It would seem reasonable to accept that a superior method of treatment for a particular section would be more likely to afford a sounder foundation for instruction on the following section. It might therefore be urged that the smaller significance of the last seven experiments was consequent upon the more effective treatment of the syllabus content of the first seven Study Sections, given to those groups, which became the control groups for the second half of the investigation.

The investigator thinks that the above reasons constitute a sound explanation of the somewhat smaller difference of general significance of the results of the second half of the investigation. There is however, another consideration which cannot be discarded, as every effort, through syllabus planning and teaching was made to ensure that each group received the same total training before proceeding to the next Study Section. It is possible that the smaller significance of the effect of the practical work could be due to the smaller ratio of support furnished for the theory in the last seven Study Sections. However, while the relative importance in significance is interesting, it is of little value compared with the outstanding finding, that even when the groups were interchanged, the experimental groups still yielded results, which clearly demonstrated a highly significant difference inthe effectiveness of the two methods of treatment.

D. Re-test Results.

As explained in the chapter of this thesis dealing with the organisation of the experimental procedure, it was intended to seek further evidence of the effectiveness of the manipulation apparatus, by applying the achievement progress tests a second time to the control groups, after they had been given an opportunity of carrying out supporting practical exercises. This procedure was used three times, but it was then abandoned, as the results obtained, which are shown in detail at Appendix L, were considered to be of very doubtful value and as the re-testing was producing unhappy effects upon the students, who voiced their disapproval of the practice, regarding it as a waste of time.

Re-Test Scores.

Test No.	1		2		3	
Application	1st	2nd	1st	2nd	1st	2nd
Total Scores	166	284	139	260	150	273
Mean Values	10.38	17.75	8.69	16.25	9.38	17.06

Inspection of the above results secured from the same control class shows that there was a very marked increase in the pupils' scores, when each of the three tests was applied a second time.

However, it is not possible to assert that these large increases were due solely to the use of the special training apparatus, for the following reasons :-

(a) After the original test, the instructor, in accordance with normal teaching practice subsequent to examinations, discussed the questions with his pupils and then gave the accepted solutions. This procedure, which might be deemed to have served either as additional instruction or as revision, materially increased the students' chances of securing better scores when the test was re-applied, even before any practical work had been undertaken.

(b) Having once been asked questions upon certain topics, the students tended subconsciously to regard any related information, which they later collected, as more noteworthy than other facts, many of which were of infinitely greater moment, because they represented the knowledge for which they had previously been asked and which they had failed to remember.

(c) The time that elapsed between the two applications of the tests considered, was in each case approximately one week, when it was estimated that many of the testees were able to recall in some detail many of the questions previously set. In fact, the investigator had several instances of pupils, who were able to recall after an interval of several weeks, not only the substance of questions, but also the four possible answers offered. To have attempted to combat this difficulty would have meant arranging to hold the repeated test a number of weeks after the associated practical work, but this would have constituted a further departure from the practice adopted with the experimental groups.

E. The Absolute Value of the Aids.

The present investigation tested the benefit derived from the use of the specially designed equipments as adjuncts to training since both the experimental and control groups spent the same number of hours over their theory instruction. It would undoubtedly have been of greater educational bearing had it been possible to assess the absolute effectiveness of the training aids by comparing the results secured in equal times by the two instructional techniques.

Any attempt to re-arrange the teaching syllabus to satisfy the demands of such an experiment would have brought the investigation into disrepute, for it would have meant that, after both experimental and control groups had spent equal times studying the same content under the two different techniques, the control groups would have proceeded to complete practical exercises. The pupils in the experimental groups could then legitimately have complained that the experiment curtailed their opportunities for study and consequently placed them at a disadvantage in comparison with their colleagues in the control groups. Such an organisation in the circumstances was inadmissible.

On theoretical grounds there might, on first thoughts, appear to be another method of solving the problem of determining the absolute value of the training aids. Reference to the syllabus at Appendix B shows the number of hours devoted to practical work by each pupil in the experimental groups. If for a particular study section, the number of such practical work hours is 'p' and the number of hours of theory instruction is 'l', it might be claimed that it would be reasonable to assume that, if the pupils in the control groups had spent the same total number of hours as those in the experimental groups studying the contents of the section, they would have achieved better progress test scores and the best estimate of such scores would be obtained by multiplying their actual test scores by the factor $\frac{p+1}{1}$. The investigator cannot accept the validity of such a procedure which is based on the hypothesis that for each individual pupil all time units are of equal importance in the assimilation of knowledge. Far from supporting a relationship of linear order between the assimilation of knowledge and instructional time, practical teaching experience would seem to indicate a variation following an exponential law. Consequently, it follows that this investigation does not permit the calculation of the absolute effectiveness of the training aids studied.

F. Conclusion.

As a result of the foregoing information it is considered that it has been shown that the special equipment produced a significant improvement in the type of training investigated, and that, as this research was based upon results yielded by a number of cases, which had been demonstrated to have constituted a normal sample, it could reasonably be accepted that the employment of these or similar teaching devices could be taken as generally beneficial to electrical and radio principles instruction of an equivalent standard.

It is felt that this research has barely tackled the fringe of the large problem of scientific training, especially where the main object of the instruction is to produce a large number of standard products. Having proved the value of the training aids as a whole, the next step should be to determine the value of each of the aids separately, and finally, the optimum propoɂtion of time to be spent between theory and practical work. Such a project would doubtless demand considerable sustained effort, but the results of such work, if correctly interpreted and suitably applied, might do much to improve methods of training.

APPENDICES.

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APPENDIX A.

SYLLABUS OF BASIC ELECTRICAL AND RADIO PRINCIPLES.

INTRODUCTION.

Outline of syllabus: fundamental requirements of radio-communication: the frequency spectrum. 1 hr

MAGNETISM AND ELECTRICITY.

Constitution of matter:- Molecules: atoms: electrons: protons: ions: mass and inertia: nature of heat: conductors and insulators: 1 hr

Magnetism:- Molecular theory of magnetism: permanent magnets: magnetic fields and flux density: magnetic field of the earth: magnetic variation: the magnetic compass. 4 hrs

Current Electricity:- Conception of electric current: electro-motive force: sources of E.M.F.: potential difference: resistance: Ohm's Law: practical units: resistances in series and parallel: effects of current viz. thermal, chemical and magnetic: electro-magnets: the magnetic circuit: polarised and unpolarised relays: temperature coefficient of resistance: examples. 7 hrs

Primary and Secondary Cells:- The primary cell:- its construction action and efficiency: types used in the Service: the secondary cell: lead-acid and nickel-alkaline types - their construction, action and efficiency: types of accumulator used in the Service 5 hrs

Care and Maintenance of Accumulators:- Initial charging: electrolyte: hydrometer: 10 hour rate: charging circuits and Type 'B' charging board: indication of fully charged state: discharged state: re-charging and capacity testing: faults: their causes and remedies: requirements of an accumulator charging-room: Forms 480 and 480A. 6 hrs

Induction:- Faraday's Law: Lenz's Law: self and mutual induction: growth and decay of current in an inductive circuit: the Henry: the simple alternator and its output waveform: Fleming's Right Hand Rule. 7 hrs

Generators and Motors:- Commutation: D.C. Generators - their construction, action and characteristics: output control: the motor principle: Fleming's Left Hand Rule: D.C. Motors - their action and characteristics: starting and speed control. 4 hrs

Electrostatics:- Charged and uncharged bodies: electrostatic field: capacity: factors governing capacity of condensers: the Farad: practical units of capacity: charge and discharge of a condenser: capacity of condensers in series and in parallel: examples: types of condensers: test and working voltages. 3 hrs

Electrical Measuring Instruments.
Construction, action and use of moving coil, moving iron, thermo-junction and electrostatic types: shunts and multipliers: ammeters, voltmeters, ohmmeters and universal instruments: ohms per volt: testmeters types 'D' and 'E': the megger and bonding tester: the wattmeter. 7 hrs

ALTERNATING CURRENT.

Revision:- A.C. waveform, frequency, instantaneous and peak values of alternating quantities: phase angle. 1 hr

Theoretical Principles:- Application of alternating voltages to a resistive circuit: R.M.S. and Mean values, form factor: application of alternating voltages to simple reactive circuits, inductive reactance, capacitive reactance, impedance and power factor: series and parallel circuits, impedance, resonance, selectivity and magnification: use of iron dust cores: the R.F. transformer, coupled circuits: the power transformer, its construction, action off and on load. 27 hrs

TELEPHONY.

Sound:- Nature of sound waves, fundamental and harmonics, frequency and pitch, amplitude and loudness: frequency requirements for intelligible speech. 1 hr.

The Microphone, Telephone and Loudspeaker:- The construction and action of (i) carbon microphone (ii) telephone receivers (iii) the electro-magnetic microphone, and (iv) the loudspeaker: the type 'F' telephone and 10 line switch-board. 4 hrs

VALVE THEORY.

Thermionic Emission. The Edison Effect: bright and dull emitters, directly and indirectly heated cathodes, space charge, evacuation and gettering. 1 hr

The Diode:- Construction and uni-directional property: characteristics and constants of hard and soft diodes. 2 hrs

Receiving and Transmitting Valves:- Construction, characteristics and constants of the triode, tetrode, pentode and beam tetrode types: common failures: demonstration of valve characteristics by means of the oscilloscope. 13 hrs

THE OSCILLOSCOPE.

The cathode ray tube, its construction and action: simple linear soft and hard time bases: shift controls: synchronising, deflection amplifiers, power supplies. 8 hrs

POWER SUPPLIES.

Batteries:- high-tension: low-tension and grid bias types and the Milnes' Unit:- their construction and maintenance. 1 hr

Rotary Transformers:- their principle of operation, construction and characteristics: smoothing and efficiency. 4 hrs

Mains Units. Principle of the rectifier action of (i) Half wave (ii) Full wave (iii) Bridge, and (iv) Voltage Doubling circuits: metal rectifiers: valve rectifiers: the construction, action, advantages and relative disadvantages of hard and soft types: precautions to be taken with mercury vapour valves: smoothing circuits. 8 hrs

Vibrators:- Construction and action: stabilisation of power supplies. 1 hr

AUDIO FREQUENCY AMPLIFICATION.

Voltage amplification. The triode as a Class 'A' Voltage Amplifier using a resistive load: dynamic characteristics: voltage amplification factor and stage gain: types of anode loads and coupling: relative stage gains: amplitude and frequency responses, distortion: instability, de-coupling and screening, use of negative feedback: battery, cathode and automatic bias. 13 hrs

Power Amplification. The triode as a Class 'A' Power Amplifier: load line for resistive load: optimum load: power output: anode dissipation and efficiency: output transformers and matching: pentodes and beam tetrodes as power amplifiers: comparison with triodes: valves in parallel. 10 hrs

Push-Pull Amplification. Principle of operation: advantages and relative disadvantages of (i) Class 'A' (ii) Class 'B' (iii) Class A-B and (iv) Positive Drive Class Amplifiers. 4 hrs

Typical Service Audio Frequency Amplifiers. Circuit details and power supplies of (i) the low power inter-communication amplifier A.1134A, and (ii) the high power modulation amplifier of the transmitter T.1131. 5 hrs

OSCILLATORS.

The Oscillatory Circuit. Discharge of a condenser through an inductance: the closed oscillatory circuit, energy losses, damped oscillations, natural frequency; the open oscillatory circuit as a source of radiation, maintenance of continuous oscillations. 4 hrs

Radio Frequency Valve Oscillators. Consideration of the circuits and action of (i) Meissner (ii) Hartley (iii) Colpitts (iv) Tuned anode tuned grid (v) Electron coupled, and (vi) Crystal oscillators: Efficiency of oscillators: Class 'C' operation. 14 hrs

TRANSMITTERS.

Simple one valve transmitter:- Development from the oscillator: production of continuous and interrupted waves: causes of frequency instability. 2 hrs.

Frequency controlled transmitters:- Addition of power amplifier stage: Class B and C operation: the Master Oscillator Power Amplifier: the crystal oscillator: their relative advantages and disadvantages: tuning: neutralising: significance of meter readings: the principle of frequency multiplication. 14 hrs.

Modulation:- Meaning: use of amplitude and frequency modulated waves: depth of modulation: side-bands: consideration of power: action, advantages and disadvantages of (i) grid (ii) anode (iii) anode and screen, and (iv) suppressor grid methods of amplitude modulation: linear amplification of modulated waves: keying, side-tone and listening through. 14 hrs.

Typical Service Ground Station Transmitters:- (i) Transmitter T.1087. The circuit: power supplies: action of filament and H.T. relays: demonstration of local control for C.W. operation: action of space frequency mechanism: necessity for remote control: remote controls , types 3 and 88: demonstration of remote operation using C.W., M.C.W. and R.T.: correct tuning procedure using wavemeter. 15 hrs.

(ii) Transmitter T.1190.Description: tuning demonstration: local and remote operation 9 hrs.

(iii) Transmitter T 1131. Circuit: power supplies: demonstration of tuning: local and remote control. 4 hrs.

PROPAGATION OF ELECTRO-MAGNETIC WAVES.

The nature of electro-magnetic waves: the ionosphere, ground and sky rays: suitability of various frequency bands for specific communication purposes. 1 hr.

Aerials:- Travelling and standing waves: Hertz and Marconi aerials: radiation resistance: effective height and form factor: polar diagrams: reflectors and directors: simple arrays. 13 hrs.

Transmission lines:- Tuned feeders: matching: limitations: untuned feeders: surge impedance;methods of matching (i) transmitters to feeders (ii) aerial to feeders: Service co-axial cables. 9 hrs.

RECEIVERS.

The incoming signal: field strength: tuning: selectivity. 1 hr.

Detection:- Meaning of and necessity for detection: methods of detection (i) diode (ii) leaky grid and (iii) lower anode bend: their advantages and dis-advantages. 5 hrs.

Simple one valve receiver:- Reception of modulated waves: use of reaction for (i) increased sensitivity (ii) increased selectivity: reception of unmodulated waves: meaning of and necessity for heterodyning: autodyne reception of C.W.: separate heterodyne. 9 hrs.

The straight receiver:- Development of the straight receiver circuit by the addition of (i) A.F. and output stages, and (ii)R.F. stages: methods of bias and of volume control: stability: decoupling, screening and filtering: limitations of straight receiver. 10 hrs.

DIRECTION FINDING.

Omni-directional properties of a vertical aerial. 1 hr.

Rotating Loop Aerial. Development of polar diagram: directional properties of loop: vertical effect and direct pickup: how minimised: the cardioid: sense finding: quadrantal error and its correction: coastal and night effects. 5 hrs.

Bellini-Tosi, Adcock and V.H.F. D/F Systems.

(i) Bellini-Tosi aerial system and goniometer: effective height: limitations. 2 hrs.

(ii) Adcock aerial system: goniometer and receiver D.F.G.25: choice of site for H/F D/F Stations: calibration: daily check. 4 hrs.

(iii) V.H.F. D/F aerial and coupling unit: sense determination: siting and calibration: daily check. 8 hrs.

Application of D/F to Navigation.

True and magnetic bearings: magnetic variation: relative bearing: compass deviation: conversion of relative bearings to true and magnetic: homing methods of fixing position. 2 hrs.

THE SUPER-HETERODYNE RECEIVER.

(i) Principle and advantages of super-heterodyne reception: choice of intermediate frequency: adjacent and second channel selectivity: detector type of frequency changer. 4 hrs.

(ii) The Ground Station Receiver R.1084. Circuit details: power supplies: tuning: re-alignment and testing. 4 hrs.

(iii) Modern frequency changers: construction: characteristics: circuits and action: tracking: padding: trimming. 4 hrs.

(iv) Automatic Volume Control: meaning and necessity: simple, delayed, quiescent and corrected methods of A.V.C. tuning indicators. 6 hrs.

(v) Modern super-heterodyne receiver circuits: different types of stages. 4 hrs.

(vi) Interference,source viz.:- (a) conducted (b) radiated: suppression by filtering: screening and bonding: aerial siting. 2 hrs.

TOTAL 318 hrs.

APPENDIX B.

METHOD 1. BASIC ELECTRICAL AND RADIO PRINCIPLES.

Study Section.	Lectures	Periods	Demonstrations and Practical Work	Periods
1.	Introduction	1		
	Constitution of Matter	1		
	Magnetism	2	Plotting magnetic fields. Demonstrations of the Principle of Magnetic Induction.	2
	Current Electricity	5	Exercises involving resistances in series and parallel. Demonstration of the thermal effect of current. Electrolysis of dilute acid and copper sulphate solution.	2
	Progress Test No. 1.			
2.	Primary and Secondary Cells	3	Demonstration of the action of simple cells: measurement of internal resistance: action of simple lead accumulator: measurement of internal resistance.	2
	Care and Maintenance of Accumulators	4	Demonstration of all types of Service accumulators and of charging room equipment: practical work in charging room: inspection of faulty accumulators.	2
	Induction	4	Demonstrations of Faraday's and Lenz's Laws.	2
			Variation of Inductance with polarising current.	1
	Progress Test No. 2.			
3.	Generators and Motors	3	Dismantling: reassembling of small machines.	1
	Electrostatics	2	Plotting rate of charge and discharge of condensers through resistances. Rate of charge of a condenser using a constant current device.	1
	Electrical Measuring Instruments	4	Conversion of moving coil instruments into milliammeters, voltmeters and ohmmeters.	3
	Progress Test No. 3.			

Study Section	Lectures	Periods	Demonstrations and Practical Work	Periods
4	Alternating Current Theory	19	Cathode ray oscilloscope demonstrations to illustrate waveform: peak value: phase angle:	1
			Experiment to investigate the variation of inductive reactance with frequency.	1
			C.R.O. and quantitative experiments to illustrate and measure (i) Variation of capacitive reactance with frequency, (ii) Series and Parallel resonance and selectivity, (iii) Action of coupled circuits, (iv) Action of power transformer on and off load.	7
	Progress Test No.4.			
5	Sound	1		
	Telephony	4		
	Thermionic Emission	1		
	The Diode	2		
	Receiving and Transmitting Valves	4	Plotting of characteristics and determination of the constants of diodes, triodes, pentodes and beam tetrodes.	8
	Progress Test No.5.			
6	The Oscilloscope	7	Use of demonstration C.R.O. to illustrate C.R.O. construction and action.	1
	Batteries	1		
	Rotary Transformers	2	Dismantling: reassembly: testing of various types of rotary transformers	2
	Mains Units	6	Wiring of power units half and full wave valve and metal rectifiers. C.R.O. demonstrations of various types of rectifier circuits.	2
	Vibrators	1		
	Progress Test No.6.			

Study Section	Lectures	Periods	Demonstrations and Practical Work	Periods
7	Audio Frequency Voltage Amplification	9	C.R.O. demonstration of Class A operation	1
			Construction of A/F amplifiers	3
	Audio Frequency Power Amplification	8	Demonstration Output Stage	2
	Push-Pull Amplification	4		
	Amplifier A.1134A.	2		
	Modulator of T.1131.	3		
	Progress Test No. 7.			
8	Oscillatory Circuit	3		
	Radio Frequency Valve Oscillators	7		
	Progress Test No. 8.			
9			C.R.O. demonstration of the coupling necessary for the maintenance of oscillations.	1
			Wiring, operating and testing of various forms of oscillators.	7
	Simple One Valve Transmitter	2		
	Frequency Controlled Transmitters	8		
	Progress Test No. 9. and Progress Test No. 8A.			
10	Modulation	8	C.R.O. demonstration of Class A, B and C operation : (i) Wiring of a power amplifier stage coupling to various types of oscillator stages. keying: (ii) Use of C.R.O. to adjust and estimate depth of modulation. Demonstration of grid and anode modulation.	6
	Progress Test No. 10 and Progress Test No. 9A.			

Study Section	Lectures	Periods	Demonstrations and Practical Work	Periods
11			(i) Wiring of MOPA and COPA transmitters for various types of modulation. (ii) Use of C.R.O. to adjust and estimate depth of modulation. Demonstrations of grid and anode modulation showing the effects of drive variations: bias and modulating voltages.	6
	Transmitter T.1087	8		
	Transmitter T.1190	3	Demonstration and manipulation of T.1087 and T.1190.	7
	Remote Control of T.1087	3		
	Remote Control of T. 1190	1	Remote Control of T.1087 and T.1190	3
	Transmitter T.1131	3	Demonstration and manipulation of T.1131.	1
	Progress Test No. 11 and Progress Test No. 10A.			
12	Propagation	1		
	Aerials	8		
	Transmission Lines	3		
	Progress Test No. 12.			
13			Aerial experiments to illustrate (i) Standing and travelling waves. (ii) Horizontal and vertical polar diagram of simple and complex arrays. (iii) Effect of height of aerial.	5
			Transmission experiments to illustrate (i) Action of tuned feeders. (ii) Different types of matching, using both balanced and unbalanced feeders. (iii) Measurement of frequency by Lecher Wire method.	6
	Receivers - The incoming signal	1		
	Detection	4		
	The One Valve Receiver	7		
	The Straight Receiver	6		
	Progress Test No. 13 and Progress Test No. 12A.			

Study Section	Lectures	Periods	Demonstrations and Practical Work	Periods
14			C.R.O. demonstration of Detection	1
			Wiring of one valve receiver for the reception of R/T and C.W.	2
	Rotating Loop Aerial	5	Wiring, testing of Straight Receivers incorporating R/F and A/F stages.	4
	Bellini-Tosi Aerial System	2		
	Adcock Aerial System	2		
	V.H.F. D/F.	2		
	Application of D/F to Navigation	2		
	Progress Test No. 14 and Progress Test No. 13A.			
15	Super-heterodyne Receiver	4	Demonstration of the signal picked up by a rotating loop aerial.	1
	Receiver R.1084	3	Demonstration and manipulation of R.1084	1
			Visit to Adcock Aerial System	2
			V.H.F. D/F Exercise	6
	Modern Frequency Changers	2		
	Automatic Volume Control	3		
	Modern Super-heterodyne Circuits	3		
	Interference	2		
	Progress Test No. 15 and Progress Test No. 14A.			
			Plotting F/C valve characteristics.	2
			Wiring of modern super-heterodyne receivers with A.V.C. and cathode ray indicators.	4
	Progress Test No. 15A. ONLY.			
	Total	209	Total	109

APPENDIX C.

METHOD 2. BASIC ELECTRICAL PRINCIPLES.

Study Section.	Lectures	Periods	Demonstrations and Practical Work	Periods
1.	Introduction	1		
	Constitution of Matter	1		
	Magnetism	2		
	Current Electricity	5		
	Progress Test No. 1.			
2.	Primary and Secondary Cells	3	Plotting magnetic fields. Demonstrations of the principle of Magnetic Induction.	2
	Care and Maintenance of Accumulators	4	Exercises involving resistances in series and parallel. Demonstrations of the thermal effect of current. Electrolysis of dilute acid and copper sulphate solution.	2
	Induction	4		
	Progress Test No.2 and Progress Test No. 1A.			
3.	Generators and Motors	3	Demonstration of action of simple cells: measurement of internal resistance. Action of simple lead acid accumulator: measurement of internal resistance.	2
	Electrostatics	2	Demonstration of all types of Service accumulators and of charging room equipment: practical work in charging room: inspection of faulty accumulators.	2
	Electrical Measuring Instruments	4	Faraday's and Lenz's Laws: demonstrations:	2
			Variation of Inductance with polarising current.	1
	Progress Test No. 3 and Progress Test No. 2A.			
4.	Alternating Current Theory	19	Dismantling and reassembly of small machines.	1
			Plotting rate of charge and discharge of condensers through resistance. Rate of charge of a condenser using a constant current device.	1
			Conversion of moving coil instruments into milliammeters, voltmeters and ohmmeters.	3
	Progress Test No. 4 and Progress Test No. 3A			

Study Section.	Lectures	Periods	Demonstrations and Practical Work	Periods
5.	Sound	1		
	Telephony	4	Cathode Ray Oscilloscope demonstrations to illustrate waveform: peak value: phase angle	1
			C.R.O. and quantitative experiments to illustrate and measure (i) Variation of inductive and capacitive reactance with frequency (ii) Series and parallel resonance and selectivity (iii) Action of coupled circuits, and (iv) Action of power transformer on and off load.	8
	Thermionic Emission	1		
	The Diode	2		
	Receiving and Transmitting Valves	4		
	Progress Test No. 5 and Progress Test No. 4A.			
6.	The Oscilloscope	7	Plotting of characteristics and determination of the constants of diodes, triodes, pentodes and beam tetrode valves	8
	Batteries	1		
	Rotary Transformers	2		
	Mains Units	6		
	Vibrators	1		
	Progress Test No. 6 and Progress Test No.5A.			
7.			Use of demonstration Oscilloscope to illustrate C.R.O. construction and action.	1
			Dismantling: reassembly: testing of various types of rotary transformers.	2
	Audio Frequency Voltage Amplification	9	Wiring of power units, using half and full wave valve and metal rectifiers: C.R.O. demonstrations of various types of rectifier circuits.	2
	Audio Frequency Power Amplification	8		
	Push-Pull Amplification	4		
	Progress Test No. 7 and Progress Test No. 6A.			
	Amplifier A. 1134A.	2	C.R.O. demonstration of Class 'A' operation	1
			Construction of A/F Amplifiers.	3
			Demonstration Output Stage	2
	Modulator of T. 1131.	3		
	Progress Test No. 7A only.			

Study Section.	Lectures	Periods	Demonstrations and Practical Work	Periods
8.	The Oscillatory Circuit	3	C.R.O. demonstration of the coupling necessary for the maintenance of oscillations.	1
	Radio Frequency Valve Oscillators	7	Wiring, operating and testing of various forms of oscillators.	7
	Progress Test No. 8.			
9.	Simple One Valve Transmitter	2		
	Frequency Controlled Transmitters	8	C.R.O. demonstration of Class A, B and C operation. (i) Wiring of a power amplifier stage, coupling to various types of oscillator stages: keying. (ii) Experiments to illustrate frequency multiplication.	6
	Progress Test No. 9.			
10.	Modulation	8	(i) Wiring of MOPA and COPA transmitters for various types of modulation. (ii) Use of C.R.O. to adjust and estimate depth of modulation. Demonstrations of grid and anode modulation, showing the effects of drive variations, bias and modulating voltages.	6
	Progress Test No. 10.			
11.	Transmitter T. 1087	8	Demonstration and manipulation of Transmitters T. 1087 and T. 1190	7
	Transmitter T. 1190	3		
	Remote Control of T. 1087	3	Manipulation and Remote Control practice of T. 1087 and T. 1190.	3
	Remote Control of T. 1190	1		
	Transmitter T. 1131	3	Demonstration and manipulation of T. 1131	1
	Progress Test No. 11.			

Study Section.	Lectures	Periods	Demonstrations and Practical Work	Periods
12.	Propagation	1		
	Aerials	8	Aerial experiments to illustrate (i) Standing and travelling waves. (ii) Horizontal and vertical polar diagrams, of simple and complex arrays. (iii) Effect of height of aerial.	5
	Transmission Lines	3	Transmission Line Experiments (i) Action of tuned feeders. (ii) Different types of matching, using both balanced and unbalanced feeders. (iii) Measurement of frequency by Lecher Wire Method.	6
	Progress Test No. 12.			
13.	Receivers - The incoming signal.	1		
	Detection	4	C.R.O. demonstration of Detection.	1
	One valve Receiver	7	Wiring of one valve receiver for reception of R/T and C.W.	2
	The Straight Receiver	6	Wiring and testing of Straight Receiver incorporating R/F and A/F stages.	4
	Progress Test No. 13.			
14.	Rotating Loop Aerial	5	Demonstration of the signal picked up by a rotating loop aerial.	1
	Bellini-Tosi Aerial System	2		
	Adcock Aerial System	2	Visit to Adcock Aerial System.	2
	V.H.F. D/F	2	V.H.F. D/F Exercise.	6
	Application of D/F to Navigation	2		
	Progress Test No. 14.			

Study Section.	Lectures	Periods	Demonstrations and Practical Work	Periods
15.	Super-heterodyne Receiver	4		
	Reweiver R. 1084	3	Practical manipulation of R. 1084	1
	Modern Frequency Changers	2	Plotting characteristics of frequency changing valves.	2
	Automatic Volume Control	3		
	Modern Super-heterodyne Circuits	3	Wiring of modern super-heterodyne receivers with A.V.C. and cathode ray indicators.	4
	Interference	2		
	Progress Test No. 15.			
	Total	209	Total	109

APPENDIX D.

ANSWER SHEET.

Non-Verbal Test No. Name. Course No.

Read the instructions printed on the cover of the Test Booklet but do NOT mark the Booklet.
Answer all questions on these answer sheets, a fresh one for each test, crossing out the incorrect solutions.
e.g. Example preceding Test No. 1. (a̸) (b) (c̸) (d̸) (e̸)

Question number.					
1.	(a)	(b)	(c)	(d)	(e)
2.	(a)	(b)	(c)	(d)	(e)
3.	(a)	(b)	(c)	(d)	(e)
4.	(a)	(b)	(c)	(d)	(e)
5.	(a)	(b)	(c)	(d)	(e)
6.	(a)	(b)	(c)	(d)	(e)
7.	(a)	(b)	(c)	(d)	(e)
8.	(a)	(b)	(c)	(d)	(e)
9.	(a)	(b)	(c)	(d)	(e)
10.	(a)	(b)	(c)	(d)	(e)
11.	(a)	(b)	(c)	(d)	(e)
12.	(a)	(b)	(c)	(d)	(e)
13.	(a)	(b)	(c)	(d)	(e)
14.	(a)	(b)	(c)	(d)	(e)
15.	(a)	(b)	(c)	(d)	(e)
16.	(a)	(b)	(c)	(d)	(e)
17.	(a)	(b)	(c)	(d)	(e)
18.	(a)	(b)	(c)	(d)	(e)
19.	(a)	(b)	(c)	(d)	(e)
20.	(a)	(b)	(c)	(d)	(e)

APPENDIX E.

Test of Normality of Distribution of Initial Test Scores. (Jenkins' Test).

Classes.	Frequencies.	Deviations.	Fd.	Fd^2.
Above 81	1	+ 8	+ 8	64
79	2	+ 7	+ 14	98
77	6	+ 6	+ 36	216
75	8	+ 5	+ 40	200
73	12	+ 4	+ 48	192
71	14	+ 3	+ 42	126
69	22	+ 2	+ 44	88
67	15	+ 1	+ 15	15
65	22	0	247	0
63	20	- 1	- 20	20
61	20	- 2	- 40	80
59	19	- 3	- 57	171
57	13	- 4	- 52	208
55	13	- 5	- 65	325
53	6	- 6	- 36	216
51	3	- 7	- 21	147
49	6	- 8	- 48	384
47	0	- 9	0	0
45	2	- 10	- 20	200
Below 45	0	0	0	0
Totals.	204		- 359	2750
			- 112	

$$\text{Mean} = 66 - \frac{2 \times 112}{204}$$

$$= 66 - 1.088$$

$$= 64.91$$

Standard Deviation

$$= 2\sqrt{\left(\frac{2750}{204}\right) - \left(\frac{112}{204}\right)^2}$$

$$= 2\sqrt{13.48 - .308}$$

$$= 2\sqrt{13.172}$$

$$= 7.23.$$

A normal distribution having the same total number of cases, the same mean and standard deviation was next constructed. A comparison using the 'chi-squared' method was then made between the theoretical frequencies and the observed frequencies of distribution :-

Classes	Observed Freq.	Deviation	Fractional Deviation	Theoretical % at or beyond this deviation	Theoretical % Frequency	Theoretical Frequency	$\frac{(f_o - f_t)^2}{f_t}$
Above 81	1	+16.09	+ 2.225	1.32	1.32	3	1.333
79	2	+14.09	+ 1.948	2.60	1.28	3	0.333
77	6	+12.09	+ 1.672	4.70	2.10	4	1.000
75	8	+10.09	+ 1.395	8.10	3.40	7	0.143
73	12	+ 8.09	+ 1.119	13.40	5.30	11	0.091
71	14	+ 6.09	+ 0.842	20.20	6.80	14	0.000
69	22	+ 4.09	+ 0.566	28.70	8.50	17	1.471
67	15	+ 2.09	+ 0.289	38.40	9.70	20	1.250
65	22	+ .09	+ 0.011	49.80	11.40	23	0.043
63	20	- 1.91	- 0.264	39.40	10.80	22	0.182
61	20	- 3.91	- 0.541	29.20	10.20	21	0.048
59	19	- 5.91	- 0.818	20.80	8.40	17	0.235
57	13	- 7.91	- 1.094	13.70	7.10	14	0.072
55	13	- 9.91	- 1.371	8.40	5.30	11	0.364
53	6	-11.91	- 1.648	5.00	3.40	7	0.143
51	3	-13.91	- 1.924	2.62	2.38	5	0.800
49	6	-15.91	- 2.201	1.40	1.22	2	8.000
47	0	-17.91	- 2.477	0.66	0.74	1	1.000
45	2	-19.91	- 2.754	0.27	0.39	1	1.000
Below 45	0				0.27	1	1.000
Total	204				100.00		18.508

The number of degrees of freedom of the observed frequency distribution is 19 since there are 20 different classes having the one fixed condition that the total number of cases is 204.

The number of degrees of freedom of the theoretically normal distribution is consequently 17 for although there are still 20 different classes there are three fixed conditions :-

(i) The total number of cases is 204.
(ii) The mean of the distribution is 64.91
(iii) The standard deviation is 7.23

Reference to 'chi-squared' tables shows that when d.f. is 17 a value of 'chi-squared' of 18.508 or greater would be expected in 40% of all random chosen samples.

APPENDIX F.

Progress Test No. 1. Question Paper. Page 1.

1. An Atom is defined as :-
   (a) The smallest particle into which a compound material will divide whilst retaining the properties of that material ?
   (b) The smallest particle of negative electricity ?
   (c) The smallest portion of matter which can enter into chemical combination or which is obtainable by chemical separation ?
   (d) An elementary particle of positive electricity equal in charge to that of an electron ?

2. How many different kinds of elements are known to science ?
   (a) 29.
   (b) 97.
   (c) 92.
   (d) 72.

3. An "Ion" is :-
   (a) A gaseous Element ?
   (b) An Atom which has lost or gained an electron ?
   (c) An electron passing along a conductor ?
   (d) Any substance not susceptible to magnetism ?

4. The property whereby a body offers opposition to any change of its motion or position of rest, is defined as its :-
   (a) Reluctance ?
   (b) Inertia ?
   (c) Negative Temperature Co-efficient ?
   (d) Specific Resistance ?

5. A Compass reads 157° at a place where the magnetic variation is 11° West, and deviation zero. The True Bearing is :-
   (a) 168°
   (b) 146°
   (c) 214°
   (d) 192°

6. Flux Density is :-
   (a) The Total number of lines of force in a magnetic field ?
   (b) The Strength of the field surrounding a current carrying solenoid ?
   (c) The number of lines of force per unit area ?
   (d) The magnifying effect of an iron core?

7. If the temperature of a conductor is Doubled, its resistance will, normally :-
   (a) Decrease ?
   (b) Increase ?
   (c) Be doubled ?
   (d) Be halved ?

8. Place the Specific Resistances of the following in descending order of numerical sequence. (Indicate 1,2,3 and 4 on answer paper.) :-
   (a) Copper.
   (b) Glass.
   (c) Iron.
   (d) Eureka.

9. A conductor is bent into a circular loop and a current passed around the loop. The total magnetic field strength "H" at the centre of the loop in Oersteds (Dynes per unit pole) is :-
   (a) $H = \frac{2\pi It}{10^6}$
   (b) $H = \frac{\omega LI}{10^8}$
   (c) $H = \frac{2\pi I}{10r}$
   (d) $H = \frac{2\pi I^2}{10d}$

10. "The fractional increase in resistance per unit length per degree rise in temperature" is :-
   (a) The Electro-Static Unit of temperature ?
   (b) The temperature co-efficient of Resistance ?
   (c) The co-efficient of Thermal Expansion ?
   (d) The Specific Resistance of a substance ?

11. The current in a circuit consisting of two resistances of equal rated value, in parallel, is only one half its expected value. The applied E.M.F. is normal. Which is the most likely fault ?
   (a) One resistance is shorted ?
   (b) One resistance is double its rated value ?
   (c) One resistance is open circuited ?
   (d) Both resistances are 50% below their rated value ?

12. The "Specific Resistance" at 20°C. of a substance is :-
   (a) The resistance between opposite faces of one cubic inch of the substance at 20°C. ?
   (b) The increase in resistance per degree rise in temperature ?
   (c) The resistance of one cubic centimetre of the substance at 20°C. ?
   (d) The resistance between opposite faces of a Unit Cube at 20°C. ?

13. A "Neutrally Biased" relay is one in which :-
    (a) The tongue remains at the "Mark" position irrespective of the direction of current through the solenoid ?
    (b) The tongue returns to "Space" when no current is flowing through the solenoid ?
    (c) The position of the tongue is determined by the direction of the current through the windings or the direction of the current on the last impulse ?
    (d) The tongue completes a circuit at both the "Mark" and "Space" positions ?

14. An E.M.F. can be produced by :-
    (a) Heating a clean copper conductor ?
    (b) Friction of certain substances ?
    (c) Passing a porcelain rod through a solenoid ?
    (d) Passing a current through a resistance ?

15. The current in a conductor is doubled. The temperature of the wire, neglecting radiation losses, will :-
    (a) Be double its original value ?
    (b) Be half its original value ?
    (c) Be one quarter its original value ?
    (d) Be four times its original value ?

16. A conductor has a resistance of 100 ohms at 20°C. Its temperature co-efficient is .004. Its resistance at 40°C. will be :-
    (a) 200 ohms ?
    (b) 180 ohms ?
    (c) 116 ohms ?
    (d) 108 ohms ?

17. Three 24v 6 watt lamps in parallel are fed by a 24 volt accumulator. The current consumption will be :-
    (a) .25 amps ?
    (b) 4 amps ?
    (c) .75 amps ?
    (d) 1.2 amps ?

18. A copper conductor (specific resistance at 20 C. = 1.724 microhms per cm. cube) is 1 km. long and has a cm. sectional area of .02 sq cms. What is its total resistance at this temperature :-
    (a) 1.724 ohms ?
    (b) 3.448 ohms ?
    (c) 8.62 ohms ?
    (d) 0.862 ohms ?

19. Two resistances are connected in parallel. The effective resistance of the combination will be :-
    (a) The sum of the two ?
    (b) The difference between the two ?
    (c) Something less than the smaller of the two ?
    (d) The product of the two ?

20. Two resistances of six ohms and twelve ohms connected in parallel are joined in series with a two ohm resistance. The combination is placed across an 18 volt D.C. source of supply. What is the wattage dissipated in the six ohm resistance :-

(a) 12 watts ?
(b) 6 watts ?
(c) 56 watts ?
(d) 24 watts ?

1. Increasing the d.c. component in an iron cored choke will :-
   (a) Increase the inductive reactance ?
   (b) Decrease the inductive reactance ?
   (c) Have no effect on the inductive reactance ?
   (d) Reduce the temperature of the windings ?

2. The best test to ascertain that the fully charged state of a lead acid accumulator has been reached is :-
   (a) Plates freely gassing ?
   (b) Positive plates a rich chocolate colour ?
   (c) The charging current has continually fallen ?
   (d) The voltage and S.G. of each has remained constant for one hour ?

3. A coil of five turns is connected to an A.C. source of supply. The current through the coil changes at the rate of 1 Amp per second. A second coil of ten turns is inductively coupled to the first. The induced E.M.F. in the second coil is one volt. Assuming no leakage losses, the mutual inductance is :-
   (a) 5 Henries ?
   (b) 2 Henries ?
   (c) 1 Henry ?
   (d) .2 Henries ?

4. The rotor of an alternator revolves at 1800 r.p.m. The machine has four pairs of field poles. The frequency of the output voltage is :-
   (a) 240 c.p.s. (b) 7200 c.p.s. (c) 120 c.p.s. (d) 60 c.p.s.

5. The Depolarising Agent in a "Leclanche" Cell is :-
   (a) A coating of Zinc Amalgamate ?
   (b) A paste of copper sulphate ?
   (c) Peroxide of Hydrogen ?
   (d) Manganese Dioxide ?

6. Doubling the Active Area of the plates in a Lead Acid accumulator will :-
   (a) Decrease the Terminal E.M.F. ?
   (b) Decrease the Capacity ?
   (c) Double the Capacity ?
   (d) Double the Terminal E.M.F. ?

7. The Electrolyte in a Nickel Alkaline Accumulator is :-
   (a) Potassium Hydroxide ?
   (b) Ammonia Sulphate ?
   (c) Cadmuim Nickel ?
   (d) Sal Ammoniac ?

8. The Specific Gravity of the electrolyte in a Nickel Alkaline accumulator on discharge :-
   (a) Decreases ?
   (b) Increases ?
   (c) Remains Constant ?
   (d) Becomes Unity ?

9. Local Action in a Primary Cell can be overcome by :-
   (a) Covering the electrolyte with a thin film of oil ?
   (b) Reducing the size of the negative electrode ?
   (c) Keeping the cell terminals clean and well greased ?
   (d) Special Treatment of the negative electrode ?

10. The cut-out on a charging board prevents :-
   (a) Excessive charge of accumulators ?
   (b) Accumulators discharging through the charging generator ?
   (c) Discharge of accumulators if "charging# fuse blows ?
   (d) Overcharge in the case of an internally shorted accumulator ?

11. Looking down on a vertical solenoid, the winding is anti-clockwise. If the top and bottom of the solenoid are connected to positive and negative respectively of a battery, the N pole of a compass needle is repelled by :-
   (a) The top of solenoid ?
   (b) The middle of solenoid ?
   (c) The bottom of solenoid ?
   (d) Both top and bottom of solenoid ?

12. "The direction of an induced E.M.F. is such that it opposes the motion producing it" is a law attributed to :-
   (a) Faraday (b) Fleming (c) Lenz (d) Newton

13. When applying "Fleming's Right Hand Rule" to a simple alternator, the thumb indicates :-
   (a) Direction of Field ?
   (b) Direction of E.M.F. ?
   (c) Polarity of Magnets ?
   (d) Direction of Rotation ?

14. Which of the following pieces is out of place in a battery charging room :-
   (a)Pliers and Hydrometer ?
   (b) Galvanised iron bowl and glass funnel ?
   (c) Form 480 and 480A ?
   (d) Lead acid accumulators and glass carboys ?

15. The best remedy for a badly sulphated cell is :-
   (a) Scrape the plates and recharge at double normal rate ?
   (b) Long recharge using weak electrolyte and low charging rate ?
   (c) Short recharge, using strong electrolyte and high charging rate ?
   (d) Charge for 10 hours at normal rate ?

16. A 120v dry battery reads 120 volts off load and 115 volts on load. The current taken is 20 m/a and the internal resistance of the battery is :-
   (a) 250 ohms ?
   (b) 57,000 ohms ?
   (c) 6,000 ohms ?
   (d) 100 ohms ?

17. Four 2v accumulators are put on charge at normal rate. Ten minutes afterwards the voltage readings obtained from each cell is 2.1, 2.9, 2.1 and 2.1 respectively. This indicates :-
   (a) One cell has an internal short circuit ?
   (b) Three cells have a high internal resistance ?
   (c) One cell is probably badly sulphated ?
   (d) The S.G. of three cells is extremely low ?

18. "Specific Gravity" of a liquid is :-
   (a) Its density as compared with that of water ?
   (b) Its weight, in grammes per cubic centimetre ?
   (c) The amount by which its density varies per degree rise in temperature ?
   (d) Its weight in grammes per cubic inch ?

19. The plates in a fully charged lead acid accumulator are :-
   (a) Pb and $Pb\ SO_4$
   (b) Pb and $Pb\ O_2$
   (c) Pb SO and $Pb\ SO_4$
   (d) Pb and $Pb\ SO_2$

20. The chief advantage of an "inert" cell, compared with a normal "Dry Cell" of similar dimensions is :-
   (a) Slightly higher output voltage obtainable ?
   (b) Less liable to deteriorate before being used ?
   (c) Much longer "working life" ?
   (d) Will enable more current to be taken ?

1. Sparking in a small generator may be reduced by :-
   (a) Decreasing the resistance of the brushes ?
   (b) Replacing carbon brushes with copper foil brushes ?
   (c) Rotating brushes against direction of the armature ?
   (d) Rotating brushes in same direction as armature is rotating ?

2. Resistance is added to the field circuit of a shunt wound generator. This will :-
   (a) Decrease output voltage ?
   (b) Increase output voltage ?
   (c) Increase speed of armature ?
   (d) Decrease speed of armature ?

3. The load current of a shunt wound generator is doubled. The terminal P.D. will :-
   (a) Increase ?
   (b) Decrease ?
   (c) Remain constant ?
   (d) Be halved ?

4. "Armature Reaction" in a motor produces :-
   (a) Friction of brushes on commutator ?
   (b) Hysteresis losses in the airgap ?
   (c) Distortion of the main field ?
   (d) Shift of the Geometrical Neutral Axis ?

5. A shunt wound self-excited motor is connected to its correct supply voltage. The motor races. The probable cause is :-
   (a) Open circuit in field winding ?
   (b) Brushes badly bedded in ?
   (c) Complete loss of residual magnetism ?
   (d) Open circuit in Armature circuit ?

6. A condenser is being charged through a resistance. $C = 4$ mfd, $R = 4$ Megs. The source of supply is 100 volts. How long will it take to charge the condenser to approx. 63.2 volts :-
   (a) 1 second ?
   (b) 8 seconds ?
   (c) 12 seconds ?
   (d) 16 seconds ?

7. Two 4 mfd condensers in parallel are joined in series with one of 8 mfds. The resultant capacity, in microfarads, will be :-
   (a) 2 (b) 4 (c) 8 (d) 16

8. A "Thermo couple" is :-
   (a) A device for controlling the speed of a motor ?
   (b) A column of heated mercury used to measure an E.M.F. ?
   (c) A device for obtaining an E.M.F. ?
   (d) The basic principle of the "Hot Wire" instrument ?

9. A 0 -5 Milliammeter of resistance 15 ohms is to be converted to a 0-30 Milliammeter. The resistance value of the shunt required will be :-
   (a) 3 ohms ?
   (b) 2.5 ohms ?
   (c) .45 ohms ?
   (d) 75 ohms ?

10. Consider a shunt wound motor generator with a common field. Reversed D.C. input will :-
   (a) Reverse polarity of output only ?
   (b) Have no effect ?
   (c) Reverse direction of rotation only ?
   (d) Reverse direction of rotation and polarity of output ?

11. The main effect of increasing the field resistance in a shunt wound motor will be :-
   (a) A decrease in speed ?
   (b) An increase in speed ?
   (c) An increased armature current ?
   (d) An increased field current ?

12. The reason for laminating the core of a motor armature is :-
   (a) To reduce the reluctance ?
   (b) To increase the permeability ?
   (c) To reduce weight ?
   (d) To prevent Eddy Currents ?

13. A moving iron ammeter can be used on A.C. because :-
   (a) The meter is made of low permeability material ?
   (b) The meter is heavily damped ?
   (c) The movement of the pointer is proportional to the heating effect of current measured ?
   (d) The induced magnetic field in the fixed and moving iron remains of same relative polarity ?

14. A moving iron and a Thermo-couple ammeter are both available. In which case would the use of the Thermo-couple instrument be preferable ?-
   (a) When measuring ordinary A.C. ?
   (b) When measuring D.C. ?
   (c) When measuring ordinary A.C. superimposed on D.C. ?
   (d) When measuring H.F. currents ?

15. Moisture causes leakage across the shunt of a moving coil ammeter. For a given current this is likely to cause :-
   (a) A high reading ?
   (b) A low reading ?
   (c) No reading at all ?
   (d) No change in accuracy of meter readings ?

16. A moving coil voltmeter takes 5 m/a for full scale deflection. Its full scale reading is 150 volts. How could this be converted so that 300 volts could be measured, ignoring resistance of moving coil :-
   (a) By increasing its resistance by 60,000 ohms ?
   (b) By decreasing its resistance by 60,000 ohms ?
   (c) By increasing its resistance by 30,000 ohms ?
   (d) By decreasing its resistance by 30,000 ohms ?

17. An ammeter having a full scale deflection of 5 amps consists of a basic meter of Resistance 95 ohms shunted by a resistance of 5 ohms. It is required to modify the instrument for a full scale deflection of 500 m/a. It will be necessary to replace the shunt by one of :-
   (a) 95 ohms ?
   (b) 9.5 ohms ?
   (c) 50 ohms ?
   (d) 950 ohms ?

18. The function of the "No Volts" coil, in a motor starter, is :-
   (a) To keep input voltage at a steady value ?
   (b) To hold starter handle in the "on" position ?
   (c) To reduce field current if supply voltage rises ?
   (d) To compensate any reduction in armature current ?

19. A 4 mfd condenser, when charged from a 100v source of supply, attains a charge of 63.2 volts in 64 seconds. What is the value of the series resistance :-
   (a) 16 ohms ?
   (b) 256 ohms ?
   (c) 16 megohms ?
   (d) 256 megohms ?

20. A condenser has a capacity of .5 mfd. The distance between the plates is doubled. What is the value of its capacity under these conditions ?
   (a) 1 mfd ?
   (b) 2.5 mfd ?
   (c) .25 mfd ?
   (d) .125 mfd ?

1. The "instantaneous value" of an alternating current is :-
   (a) Its equivalent value of D.C. ?
   (b) .707 times its maximum value ?
   (c) Its value at any given instant ?
   (d) Its value at the beginning of each cycle ?

2. The peak value of an alternating current is :-
   (a) Measured from max. positive peak to max. negative peak ?
   (b) Measured from top of one positive peak to top of next positive peak ?
   (c) Its max. value either positive or negative ?
   (d) .707 times its R.M.S. value ?

3. The R.M.S. value of an alternating current is :-
   (a) The current as measured by an ammeter which is accurate when used in a D.C. circuit ?
   (b) The current at any given instant ?
   (c) 1.414 times its D.C.equivalent ?
   (d) The max. value of current during any cycle ?

4. "Periodic Time" as applied to a sine curve is :-
   (a) The time between any peak positive value and the next peak negative value ?
   (b) A measure of the damping of an A.C. circuit ?
   (c) The time taken for one complete cycle ?
   (d) The frequency of the circuit ?

5. The impedance of a circuit consisting of L, C and R in series is given by the formula :-
   (a) $\sqrt{R^2 + (\omega L \sim \frac{1}{\omega C})^2}$
   (b) $\frac{E}{\sqrt{R^2 + (\omega L)^2}}$
   (c) $1885\sqrt{LC}$
   (d) $\sqrt{(\omega L \sim \frac{1}{\omega C})^2}$

6. The resonant frequency of a circuit consisting of L and C in series is given by :-
   (a) $\sqrt{R^2 + (\omega L \sim \frac{1}{\omega C})^2}$
   (b) $\frac{1}{2\pi\sqrt{LC}}$
   (c) $1885\sqrt{LC}$
   (d) $2\sqrt{\frac{L}{C}}$

7. A circuit consisting of L and C in parallel is placed across an A.C. source of supply. Minimum current will be taken from the supply when :-
   (a) Circuit frequency much higher than that of supply ?
   (b) Circuit frequency much lower than that of supply ?
   (c) Circuit tuned to resonate with supply and the resistance of L small ?
   (d) Circuit tuned to resonate with supply and the resistance of L large ?

8. In a series A.C. circuit, consisting of L, C and R, an increase in resistance will :-
   (a) Increase the angle of lag or lead ?
   (b) Decrease the angle of lag or lead ?
   (c) Reverse the phase angle ?
   (d) Have no effect upon the phase angle ?

9. Which of the following is correct :-
   (a) $\sqrt{R^2 + (\omega L \sim \frac{1}{\omega C})^2}$ = Inductive Reactance
   (b) $2\pi f L$ = Inductive Reactance
   (c) $\frac{1}{2\pi\sqrt{LC}}$ = Inductive Reactance
   (d) $\sqrt{R + (\omega L)^2}$ = Inductive Reactance

10. "Phase Angle" is :-
   (a) The angle between the current in the Inductive and Capacitive branches of a circuit ?
   (b) The angle between the applied alternating voltage and current in any one branch of a parallel circuit containing L, C and R ?
   (c) The angle between the applied alternating voltage and the resultant current ?
   (d) The angle between applied and induced E.M.F.s ?

11. An inductance of 2,000 microhenries is in series with a capacity of .0005 mfd. Which of the following gives the frequency of this circuit ?
   (a) $\frac{10^6}{2\pi}$ c.p.s.
   (b) 2,000 c.p.s.
   (c) $1885\sqrt{LC}$ c.p.s.
   (d) $\sqrt{R^2+(\omega L \sim \frac{1}{\omega C})^2}$ c.p.s.

12. A mica condenser is connected across a 230V A.C. source of supply. What will be the maximum voltage across the condenser :-
   (a) 275V (b) 300V (c) 325V (d) 350V

13. In a parallel resonant circuit consisting of L, C and R, the impedance at resonance is :-
   (a) QL (b) Q^2R (c) RL (d) X^2R

14. The impedance of a condenser and resistance in parallel is least :-
   (a) At very low frequencies ?
   (b) At very high frequencies ?
   (c) When the reactance of the condenser equals the resistance ?
   (d) For Direct Current ?

15. A circuit consists of a condenser and resistance in parallel. If a small inductance is placed in series with the condenser the phase angle between total current and applied voltage :-
   (a) Decreases ?
   (b) Increases ?
   (c) Remains unaltered ?
   (d) Increases to 90° ?

16. A coil has a reactance of 100 ohms and a resistance of 2 ohms. The equivalent shunt resistance is :-
   (a) 200 (b) 1,000 (c) 2,000 (d) 5,000

17. In a series resonant circuit having a Q of 50 the applied voltage is 20. The voltage across the condenser is :-
   (a) 50 (b) 500 (c) 1,000 (d) 2,000

18. A series resonant circuit at frequencies below the resonant frequency presents :-
   (a) Inductive reactance ?
   (b) Capacitive reactance ?
   (c) No reactance ?
   (d) Pure resistance ?

19. The power factor of circuit comprising resistance and inductance in parallel is :-
   (a) Greater than unity ? (b) Less than unity ?
   (c) Equal to unity ? (d) Zero ?

20. An inductance of reactance 11 ohms, a capacity of reactance 8 ohms, and a resistance of 4 ohms are connected in series. If the current through the circuit is 2 Amps R.M.S., the R.M.S. value of applied voltage must be :-
   (a) 46 volts. (b) 402 volts. (c) 754 volts. (d) 10 volts.

1. The "Pitch" of a note depends upon :-
   (a) Its frequency ?
   (b) The degree of disturbance producing the sound ?
   (c) The number of overtones contained in the note ?
   (d) Its persistency ?

2. A telephone receiver is inserted into a circuit tuned to 500 c.p.s. but a note of 1000 c.p.s. is heard :-
   (a) Telephone windings are in series ?
   (b) Telephone windings are in parallel ?
   (c) Permanent magnets are too strong ?
   (d) Permanent magnets have lost their magnetic properties ?

3. The function of a "Hum-bucking" coil on an energised loud speaker is :-
   (a) To prevent production of Harmonics ?
   (b) To attenuate high notes ?
   (c) To minimise mains hum ?
   (d) To give better frequency response ?

4. The Baffle on which a loud speaker is fitted will :-
   (a) Decrease high note response ?
   (b) Increase low note response ?
   (c) Decrease low note response ?
   (d) Have no effect upon frequency response ?

5. The "Emission" in a diode valve mainly depends upon :-
   (a) Filament voltage ?
   (b) Distance between Anode and filament ?
   (c) Size of Anode ?
   (d) The degree of vacuum inside the tube ?

6. The Ra and Gm of a triode valve are given as 8000 ohms and 4 ma/v respectively. Its amplification factor will be :-
   (a) 2 (b) 4 (c) 12 (d) 32

7. The "mu" of a valve is :-
   (a) A comparison between Anode Current and Grid Volts ?
   (b) Its A.C. resistance between Cathode and Anode ?
   (c) Comparison between the changes of Anode and Grid volts required to produce the same change in Anode Current ?
   (d) A measure of its emission ?

8. Which of the following is a good indication of a soft triode :-
   (a) Excessive grid current ?
   (b) Low anode current ?
   (c) Reversed grid current ?
   (d) No anode current ?

9. Under static conditions, an increase of 2 volts bias or a decrease of 20 volts H.T. alters the Anode current of a valve by one m/a. The Ra of the valve under these conditions is :-
   (a) 10,000 ohms ?
   (b) 20,000 ohms ?
   (c) 40,000 ohms ?
   (d) 1,000 ohms ?

10. Under static conditions, an increase of 2 volts bias or a decrease of 40 volts H.T. alters the Anode current by 2 m/a. The amplification factor of the valve is :-
   (a) 80 (b) 4,000 (c) 4 (d) 20

11. "Mutual Conductance" in a valve is :-
   (a) The ratio of the change in Anode current for a given change in Grid Volts ?
   (b) The ratio of the change in Anode volts to the change in Grid volts when both produce the same change in Anode current ?
   (c) The ratio of the voltage developed across the Anode load to the voltage applied between Grid and Cathode ?
   (d) The ratio of Inter-electrode capacity between Anode and Grid to Anode and Cathode capacity ?

12. "Space charge" in a triode is :-
   (a) The potential on the grid ?
   (b) Electrons surrounding the Anode due to secondary emission ?
   (c) The charge between Anode and Grid ?
   (d) Electrons surrounding the Cathode ?

13. A "Hard valve" is one in which :-
   (a) The degree of vacuum is very high ?
   (b) A gas has been introduced to reduce the degree of vacuum ?
   (c) The envelope is constructed of metal to withstand rough usage ?
   (d) The electrodes are constructed of special hard drawn copper ?

14. The coating on the cathode of a valve is designed to :-
   (a) Reduce inter-electrode capacity ?
   (b) Increase emission ?
   (c) Reduce emission for a given temperature ?
   (d) Reduce "Space charge" ?

15. One effect of inserting a suppressor grid into a Tetrode is :-
   (a) A reduction of Cathode emission ?
   (b) Removal of the Kink in the Anode characteristic ?
   (c) A decrease in the grid-anode capacity ?
   (d) A decrease in the grid-cathode capacity ?

16. One feature of a R.F. pentode valve is that Anode current is practically independent of :-
   (a) Control grid voltage ? (b) Suppressor grid voltage ?
   (c) Anode voltage ? (d) Heater voltage ?

17. Load lines plotted on the Anode Characteristics of an output valve enable one to deduce :-
    (a) The heater voltage required ?
    (b) The value of the maximum signal that the valve can handle without exceeding permissible distortion limit ?
    (c) The Grid-Anode capacity of the valve ?
    (d) The cathode emission of the valve ?

18. A variable-mu valve is one in which :-
    (a) The Amplification factor increases as the bias is increased ?
    (b) The Amplification factor decreases as the bias is increased ?
    (c) The mutual conductance increases as the bias is increased ?
    (d) The mutual conductance decreases as the bias is increased ?

19. A triode is saturated when :-
    (a) It no longer possesses a perfect vacuum ?
    (b) The maximum anode dissipation is exceeded ?
    (c) The valve is operating without a space charge ?
    (d) When an increase in Va causes a drop in Ia ?

20. The Gm of two similar valves in parallel is :-
    (a) Equal to the Gm of one of them ?
    (b) The reciprocal of the sum of the reciprocal of the two Gm.s ?
    (c) Half the Gm of one of them ?
    (d) Twice the Gm of one of them ?

1. "A time-base circuit employing a constant current charging device" suggests the use of :-
   (a) A pentode valve ?
   (b) An exceptionally large capacity ?
   (c) An exceptionally small capacity ?
   (d) A resistance with a high Temperature Co-efficient ?

2. The "Brilliancy" of an oscilloscope is controlled by :-
   (a) The second-anode potential ?
   (b) The coating on the screen ?
   (c) The grid potential ?
   (d) The first-anode potential ?

3. The "Focus" of an oscilloscope is controlled by :-
   (a) The second-anode potential ?
   (b) The shape of the tube ?
   (c) The grid potential ?
   (d) The first-anode potential ?

4. One big advantage of a "Hard", (in comparison with a "Soft") time base, is that it will :-
   (a) Work on very low frequencies ?
   (b) Work on very high frequencies ?
   (c) Be more linear at intermediate frequencies ?
   (d) Require a lower working voltage ?

5. The big disadvantage of the "soft" time-base is due to :-
   (a) The low working voltage ?
   (b) Ionisation of the gas ?
   (c) Necessity of an extra "control grid" in the C.R. tube ?
   (d) The comparative size of the C.R. tube ?

6. The frequency of a time-base circuit is given as 1,000 c.p.s. The "Y" plate is connected to an alternating source of supply and the "trace" appears as 50 complete cycles on the screen. The frequency of the supply :-
   (a) Is 200 c.p.s. ?
   (b) Is 50,000 c.p.s. ?
   (c) Is 50 c.p.s. ?
   (d) Cannot be calculated from information given ?

7. The display on a double beam oscilloscope appears at two traces in antiphase. This indicates that the two voltages being examined are:-
   (a) A fundamental and a harmonic ?
   (b) At two frequencies slightly apart ?
   (c) In antiphase with each other ?
   (d) In phase with each other ?

8. Doubling the voltage on the first anode of a C.R.T. will, theoretically :-
   (a) Double its sensitivity ?
   (b) Halve its sensitivity ?
   (c) Halve the "Brilliance" ?
   (d) Prevent accurate "Focus" ?

9. The return path of the electrons, after striking the screen of a C.R. tube is :-
   (a) Via the ionised gas inside the tube ?
   (b) Via the capacity existing between screen and chassis ?
   (c) Via a special coating on the inside of the C.R.T. envelope ?
   (d) Via the "X" plate capacity to earth ?

10. In a full-wave power pack, using condenser input filter the "no-load" voltage across the smoothing condenser will be equal to :-
   (a) R.M.S. value of the voltage developed across the whole secondary winding ?
   (b) R.M.S. value of the voltage developed across half the secondary winding ?
   (c) The mean value, per half cycle, of the voltage developed across half the secondary winding ?
   (d) The peak value of the voltage developed across half the secondary winding ?

11. In a full-wave power pack, using the choke input filter, the "no load" voltage across the smoothing condenser will be equal to :-
   (a) R.M.S. value of the voltage developed across the whole secondary winding ?
   (b) R.M.S. value of the voltage developed across half the secondary winding ?
   (c) The mean value, per half cycle, of the voltage developed across half the secondary winding?/
   (d) The peak value of the voltage developed across half the secondary winding ?

12. In a full-wave rectifier, the common value of the reservoir condenser, in microfarads, is :-
   (a) 2 (b) 4 (c) 8 (d) 32

13. The common value (in Henries) of smoothing choke used in a receiver power supply is :-
   (a) .1 (b) 1 (c) 10 (d) 100

14. A reasonable value of the d.c. resistance of a smoothing choke in a receiver power supply is of the order of :-
    (a) 1 ohm (b) 10 ohms (c) 100 ohms (d) 1000 ohms

15. A 500-0-500 volt transformer with input tappings at 10 volt steps from 200 to 250 is available. If an A.C. source of supply of 230 volts is connected to the 250 volt tapping, what is the maximum R.M.S. voltage you could obtain from the secondary ? -
    (a) 1000 (b) 1414 (c) 920 (d) 1626

16. The peak to mean anode current ratio is least with :-
    (a) Half wave rectifier with condenser input filter ?
    (b) Half wave rectifier with choke input filter ?
    (c) Full wave rectifier with choke input filter ?
    (d) Full wave rectifier with condenser input filter ?

17. A power supply employs a full wave rectifier. The mains frequency is 50 c.p.s. The ripple frequency is :-
    (a) 50 (b) 100 (c) 25 (d) 150

18. In a voltage doubler circuit, on "no load", the inverse voltage is equal to :-
    (a) Twice the R.M.S. value of the voltage across the transformer secondary ?
    (b) Twice the peak value of the voltage across the transformer secondary ?
    (c) Twice the average value, per half cycle, of the voltage across the transformer secondary ?
    (d) The peak value of voltage across the transformer secondary ?

19. In a serviceable metal rectifier, the ratio of the backward to forward resistance of the Elements is of the order of :-
    (a) 10-1 (b) 100-1 (c) 1000-1 (d) 10,000-1

20. The elements in a metal rectifier are usually :-
    (a) Carborundum and steel ?
    (b) Copper and copper oxide ?
    (c) Steel and eureka ?
    (d) Zincite and copper oxide ?

1. The following facts are given in respect of the first stage of a resistance-capacity coupled A.F. Amplifier :-
   "MU" of valve 13.5
   A.C. Res. of valve 4 Kilohms.
   Anode load Res. 8 Kilohms.
   A.F. input to grid 2 volts R.M.S.
   What R.M.S. voltage would you anticipate across the Anode Load Resistance ?
   (a) 27 volts (b) 18 volts (c) 9 volts (d) 6 volts

2. The resistance forming the Anode Load of an A.F. R.C.C. Amplifier is shunted by a capacity of 50 micro-micro-farads. The frequency response curve of the stage will :-
   (a) Be affected at the low frequency end of the range ?
   (b) Be affected at the high frequency end of the range ?
   (c) Be affected at one particular intermediate frequency ?
   (d) Not be affected in the audio range ?

3. A note, frequency $\frac{10^4}{2\pi}$ c.s., is being amplified by a two stage amplifier. The voltage developed across the load resistance of V_1 is 20 volts. The coupling condenser and Grid leak of V_2 are .01 mfd and 1 megohm respectively. What is the voltage input to the second valve, to the nearest volt. (Work on rough paper. Give answer on "Answer" paper.)
   (a) 20 volts (b) 19 volts (c) 10 volts (d) 1 volt

4. The coupling condenser in a R.C.C. stage is connected between the bottom of the Anode Load of V_1 and the top of the grid resistance of V_2 . How should the reactance of this condenser at mid-band frequency compare with the grid resistance of V_2 :-
   (a) Be at least twice as large ?
   (b) Be approximately equal ?
   (c) Be comparatively small ?
   (d) Be of any value, since it has no bearing on amplification ?

5. Doubling the capacity of the coupling condenser in an A.F. amplifier will, theoretically :-
   (a) Increase the L.F. response ?
   (b) Decrease the L.F. response ?
   (c) Decrease the H.F. response ?
   (d) Reduce the frequency range ?

6. The Anode Load of a R.C.C. stage is equal to $4R_a$. The V.A.F. of this stage will be :-
   (a) Four times "MU" ?
   (b) Three times "MU" ?
   (c) .8 times "MU" ?
   (d) .25 times "MU" ?

7. The following facts are given in respect of the first stage of an A.F. Amplifier :-
"MU" of valve 10.
Anode Load 2H. (Resistance and Self-Capacity - Nil.)
A.F. Input. 2 volts R.M.S. at $\frac{10^4}{2\pi}$ cycles per second.
A.C. Resistance of valve. 10 K.
What is the approximate voltage developed across the Anode Load ?
(Work on rough paper. Give answer on the "Answer" sheet.)

8. A single valve is employed as an A.F. Amplifier. When a 1 K/C signal is applied to the stage, the meter indication of Anode current feed will :-
(a) Increase ?
(b) Decrease ?
(c) Remain constant ?
(d) Follow the Input Signal variations ?

9. The optimum load for an output triode is quoted by the makers as 2,000 ohms. A loudspeaker of 2.5 ohms impedance is to be matched to the valve. Which of the following is the best transformer to use :-
(a) Ratio 10:1 (b) Ratio 20:1 (c) Ratio 30:1 (d) Ratio 40:1

10. In an A.F. Amplifier an indirectly heated valve with Cathode Bias is employed. Which of the following is the most suitable valve of cathode decoupling condenser to use :-
(a) .01 mfds. (b) .1 mfds. (c) 1 mfd. (d) 10 mfds.

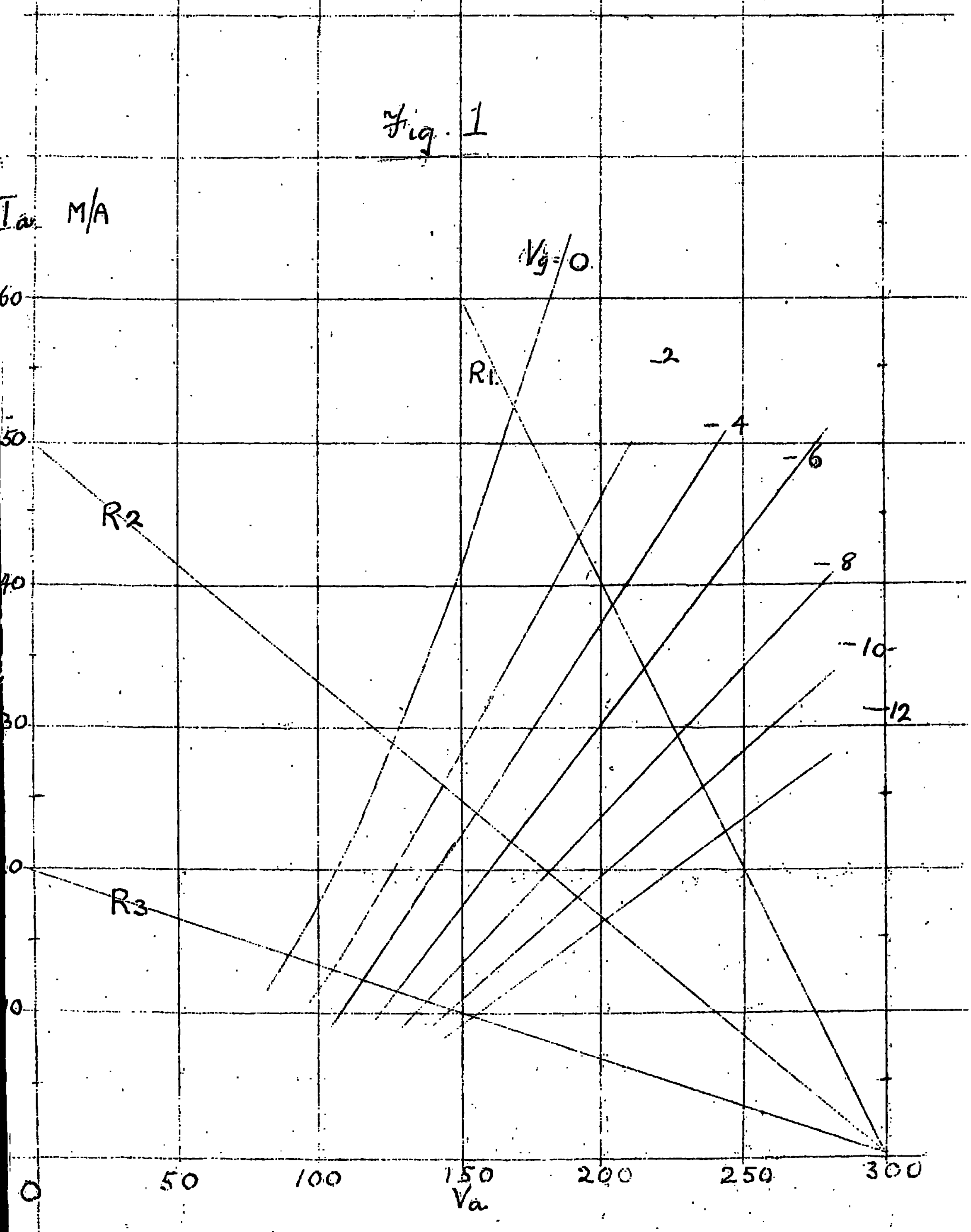
11. In a two-stage A.F. Amplifier the primary effect of the input capacity of the second stage will be to :-
(a) Increase the L.F. response ?
(b) Decrease the L.F. response ?
(c) Increase the H.F. response ?
(d) Decrease the H.F. response ?

12. A triode stage should not follow a pentode stage, as the :-
(a) Input capacity will shunt the Anode load ?
(b) Drive to the triode will be excessive ?
(c) Harmonic content of the output will br increased ?
(d) Low frequency cut-off will be increased ?

13. In the output stage of an amplifier, omission of the cathode coupling condenser will :-
(a) Decrease the gain and increase the Harmonic content of the output ?
(b) Decrease the gain and flatten the frequency response ?
(c) Increase the gain ?
(d) Increase the Anode current taken by the stage ?

Valve Characteristic Diagram.

Fig. 1



14. In a high gain A.F. amplifier the primary purpose of screening the Input stage is :-
   (a) To prevent radiation from the stage ?
   (b) To keep the first two stages operating at a constant temperature ?
   (c) Inorder to prevent the full gain of the amplifier being applied to induced interference ?
   (d) To diminish the effects of "Hand-Capacity" ?

15. In a R.C.C. amplifier the resistance of the coupling capacity must be high :-
   (a) To avoid the application of Positive bias to the following stage ?
   (b) To maintain the gain of the stage constant at all frequencies ?
   (c) To prevent negative feedback to the previous stage ?
   (d) To enable the use of a high value of grid leak in the following stage ?

The following questions are to be answered by using the graphs shown in figure 1. These curves must not be marked in any way and separate scrap or graph paper is to be used for calculation. Give your answers only on the "Answer" paper. Figure 1 shows the Anode characteristics of the valve used in a R.C.C. stage of an A.F. amplifier. The H.T. supply is 300 volts.

16. With an input of 3 volts R.M.S. what bias would you apply to the valve ?

17. With an input of 3 volts R.M.S. which anode load (from R_1 R_2 R_3) would you select in order to obtain optimum voltage amplification ?

18. What is the value of the resistance chosen as your answer to question 17 ?

19. Plot the Dynamic Mutual characteristic of the valve with R_1 as its Anode load and H.T. 300 volts. With an input of 3 volts R.M. S. will the voltage amplification be :-
   (a) Poor, with pronounced 3rd Harmonic Content ?
   (b) Poor, with negligible 2nd Harmonic Content ?
   (c) Good, with pronounced 3rd Harmonic Content ?
   (d) Good, with negligible 2nd Harmonic Content ?

20. What is the Ra of the valve assuming H.T. to be 300 volts and Vg to be minus 6 volts :-

(a) 5 Kilohms (b) 4 Kilohms (c) 3 Kilohms (d) 2 Kilohms
To nearest Kilohm.

1. "A simple oscillatory circuit will not oscillate unless its resistance is less than $2\sqrt{\frac{L}{C}}$" is :-
   (a) True (b) False

2. "In order to maintain oscillation, the varying anode-cathode and grid-cathode potentials of an oscillator must be in phase with each other" is :-
   (a) True (b) False

3. "In a Hartley oscillator employing a triode, one end of the tuned circuit is taken to anode, the other end to grid, and the cathode connected (as far as H/F is concerned) to a point in the tuned circuit between the anode and grid ends in order to obtain the correct phasing between anode and grid voltages" is :-
   (a) True (b) False

4. "On tuning a T.A.T.G. oscillator there is a sharp dip in anode current. This is because the self-bias built up is maximum when the oscillator is correctly tuned" is :-
   (a) True (b) False

5. A tuned-anode coupled grid oscillator tends to "Squeg" at the high-frequency end of the range. "This difficulty may be avoided by increasing the coupling between anode and grid circuits" is :-
   (a) True (b) False

6. "In a Colpitts oscillator the condenser in the tuned circuit between grid and cathode is smaller than the condenser between anode and cathode" is :-
   (a) True (b) False

7. "A Pierce oscillator gives a richer Harmonic content than a tuned-anode crystal-grid oscillator" is :-
   (a) True (b) False

8. "An oscillator with a tuned-anode circuit must be operated in Class A in order to ensure distortionless output" is :-
   (a) True (b) False

9. "A crystal-controlled oscillator is required to generate odd Harmonics. A triode is preferable to a pentode in this stage" is:-
   (a) True (b) False

10. "In any oscillator it is merely necessary for the valve to act asan amplifier when the feed-back will overcome the decrement of the frequency-fixing circuit" is :-
    (a) True (b) False

11. It is desired to construct a simple tuned-grid coupled anode oscillator to operate at about 1,000 cycles per second. The condenser to be used is one of .0025 mfds. Which of the following inductances is required :-
    (a) 10 Henries ?
    (b) 100 Millihenries ?
    (c) 10 Microhenries ?
    (d) 10 Millihenries ?

12. "Oscillators employing grid-leak bias are always self-starting whereas oscillators employing a fixed bias that places the operating point close to, or beyond cut-off may not be self-starting" is :-
    (a) True (b) False

13. "The lower the efficiency of an oscillator the smaller will be the Harmonic Content" is :-
    (a) True (b) False

14. "The frequency of an oscillator is dependent upon the voltage applied to the valve" is :-
    (a) True (b) False

15. "The stability of a T.A.T.G. oscillator may be improved by inserting a blocking condenser and resistance between anode and grid" is :-
    (a) True (b) False

16. If a parallel-fed oscillator suddenly takes a high feed current and refuses to oscillate, name two of the following faults which may be responsible for this effect :-
    (a) Burnt out grid-leak ?
    (b) Short across tuning condenser ?
    (c) Burnt out R.F. choke ?
    (d) Disconnected blocking condenser ?

17. "In the electron-coupled oscillator circuit, the cathode, screen-grid, and control grid of a pentode or screened grid valve are operated as a triode oscillator. Any of the electrodes serving as the anode is" is :-
    (a) True (b) False

18. "If the load on an oscillator is increased, the circulating current in the oscillator 'tank-circuit' will increase" is :-
    (a) True (b) False

19. An ordinary flash-lamp bulb can best be used to indicate that an oscillator is working by :-

(a) Placing it in series with the heater leads ?
(b) Placing it across an inductance coupled to the 'tank-circuit' ?
(c) Placing it in series with the 'tank-circuit' ?
(d) Placing it in parallel with the 'tank-circuit' ?

20. In a tuned-anode crystal-grid oscillator the anode circuit should be :-

(a) Tuned to a frequency lower than that of the crystal ?
(b) Tuned to a frequency higher than that of the crystal ?
(c) Tuned to the same frequency as that of the crystal ?
(d) Aperiodic ?

1. In a simple two valve transmitter using a triode P.A. neutralising is employed to :-
   (a) Overcome the damping losses of the oscillatory circuit ?
   (b) Obtain the correct phase relationship between anode and grid voltages ?
   (c) Reduce the effect of inter-electrode capacity between grid and cathode circuits ?
   (d) Overcome the coupling effect of inter-electrode capacity between grid and anode circuits ?

2. If the neutralising circuit in a transmitter employing a triode P.A. stage was omitted, anode and grid circuits might operate as a T.A.T.G. oscillator.
   (a) True (b) False

3. In a M.O.P.A. circuit the tighter the coupling between the two stages the better the frequency stability.
   (a) True (b) False

4. In a M.O.P.A. the first stage is usually worked at low power in comparison with the latter. The object of this is primarily :-
   (a) To keep its temperature low and maintain frequency stability ?
   (b) To prevent overdriving the P.A. grid circuit ?
   (c) To increase the efficiency of the M.O. stage ?
   (d) To provide the correct automatic bias for the P.A. stage ?

5. Using a crystal oscillator the correct tuning of the anode circuit is :-
   (a) 10% on the 'slow' side of the dip ?
   (b) 10% on the 'fast' side of the dip ?
   (c) At the peak of the dip ?
   (d)

6. When using a transmitter employing a Pierce Oscillator the crystal forms a selective feedback path between anode and grid circuits.
   (a) True (b) False

7. A pure resistance can be used as the anode feed of a Pierce Oscillator.
   (a) True (b) False

8. The P.A. stage of a C.W. transmitter is usually operated under Class C conditions and therefore :-
   (a) The harmonic content of the output is reduced ?
   (b) The efficiency of the stage is reduced ?
   (c) The efficiency of the stage is increased ?
   (d) Neutralising becomes less necessary ?

9. A transmitter aerial ammeter is usually :-
   (a) A moving coil meter ?
   (b) A thermo-junction meter ?
   (c) A moving iron meter ?
   (d) An electro-static meter ?

10. Pentodes used as P.A. valves are not usually neutralised for H.F. working as the screen of the valve is held at R.F. zero potential thus minimising the coupling between anode and grid circuits.
   (a) True (b) False

11. A push-pull frequency multiplication stage is suitable for the generation of odd harmonics of the drive frequency.
   (a) True (b) False

12. In a frequency multiplier stage the larger the angle of flow of anode current the greater will be the harmonic content of the output.
   (a) True (b) False

13. In comparison with a triode a pentode when used to give the same output as a P.A. requires a larger grid drive.
   (a) True (b) False

14. A push-pull power amplifier stage is to be preferred as it permits a more symmetrical layout of components.
   (a) True (b) False

15. On checking with a receiver the output of a transmitter spurious ultra high frequency radiations are heard. This trouble will probably be removed by including 100 ohm composition resistors in grid, screen and anode leads.
   (a) True (b) False

16. If the anode lead of the P.A. valve is connected nearer the H.T. feed end of the anode coil, the anode load in the valve is increased.
   (a) True (b) False

17. A satisfactory method of keying the pentode or tetrode P.A. stage of a transmitter is to open the screen supply circuit.
   (a) True (b) False

18. On tuning the previous stage to a Class C bias frequency multiplier the anode current of the latter will dip to a minimum.
   (a) True (b) False

19. A key click filter is simply a delay device in the H.T. circuit preventing sharp changes in H.T. current.
   (a) True (b) False

20. In a suitably driven high efficiency Class C P.A. stage for D.C. input of 100 watts, an R.F. output should be expected of :-

(a) 100 watts ?
(b) 75 watts ?
(c) 50 watts ?
(d) 25 watts ?

1. If a carrier wave is Amplitude Modulated, the amplitude of the modulation envelope varies at the modulation frequency.
   (a) True (b) False

2. If a carrier wave of frequency 1 mc/s is amplitude modulated by a modulating tone of 1000 c/s the upper side band will have a frequency of :-
   (a) 999 kc/s ?
   (b) 999.9 kc/s ?
   (c) 1001 kc/s ?
   (d) 1001.1 kc/s ?

3. If a transmitter originally set up for C.W. transmission has its P.A. stage biased back so that the aerial current is reduced to 50% of its original value and then is modulated to an average depth of 40% the power now radiated in comparison with the original C.W. radiation is approximately :-
   (a) 4% decrease ?
   (b) 48% decrease ?
   (c) 22.5% increase ?
   (d) 73% decrease ?

4. If the P.A. stage of a transmitter is 75% efficient and the C.W. power radiated is 30 watts, assuming this stage can be 100% modulated without varying the bias condition of operation, the output power of the final modulator stage must be, assuming anode modulation used.
   (a) 15 watts (b) 20 watts (c) 60 watts (d) 80 watts

5. The average power dissipated at the anode of P.A. valve (one) in Q.4 under modulated conditions is :-
   (a) 5 watts (b) 10 watts (c) 15 watts (d) 20 watts

6. Assuming that one valve is used as the final modulator mentioned above then this valve will have a smaller anode dissipation than the P.A. stage.
   (a) True (b) False

7. If the P.A. stage of a transmitter (single valve) under unmodulated conditions takes a feed current of 80 mAs (H.T. supply 1000 v.) then for anode modulation using a single valve output stage (optimum load 500 ohms) in the modulator, the modulation transformer employed should have a ratio of :-
   (a) 5 : 1 (b) 3.1 : 1 (c) 10 : 1 (d) 25 : 1

8. In an amplitude modulated P.A. stage over-modulation results in the generation of sidebands corresponding to spurious harmonics of the modulating frequencies.
   (a) True (b) False

9. Since a pentode has three electrodes - anode, suppressor grid and screen controlling the electron flow in the valve, such a valve can be fully modulated by applying the modulating voltage to any one of these three electrodes.
   (a) True (b) False

10. A grid modulated P.A. stage always uses leak and condenser bias.
   (a) True (b) False

11. Before the P.A. stage of a transmitter can be grid modulated it must be operated under Class C conditions.
   (a) True (b) False

12. If adjacent double-side-band R.T. transmitters are arranged to have a carrier difference of 9 kc/s the higher end of the modulation range is limited to :-
   (a) 4500 c/s (b) 6000 c/s (c) 6666 c/s (d) 9000 c/s

13. If a pentode valve is both anode and screen modulated, the screen decoupling condenser chosen should be :-
   (a) Of low reactance to carrier frequency only ?
   (b) Of low reactance to carrier frequency and high reactance to modulation frequencies ?
   (c) Of low reactance to both carrier and modulation frequencies ?
   (d) Value not critical usual 0.1 mfd suitable ?

14. The pentode P.A. stage of a transmitter gives maximum C.W. output power when a positive bias of 30 volts is applied to the suppressor grid. If the output power is reduced to one quarter when the bias on the suppressor grid is changed to a negative value of 20 volts, what approx. R.M.S. value of modulation voltage is required for 100% modulation :-
   (a) 100 volts (b) 70 volts (c) 50 volts (d) 35 volts

15. The output waveform of a R.T. transmitter is viewed on an oscilloscope. The trapezoidal figure obtained has a minimum height of 3 cms. and a maximum height of 5 cms. What is the depth of modulation ?
   (a) 66.6% (b) 60% (c) 40% (d) 25%

16. The anode load of an anode modulated transmitter should have a circuit amplification factor which has a low value. This is to :-
   (a) Prevent the radiation of harmonics ?
   (b) Avoid discrimination against the higher modulation frequencies ?
   (c) Facilitate matching between the anode circuit and the modulation amplifier ?
   (d) Facilitate matching between the anode circuit and the aerial system ?

17. When a transmitter is 100% modulated the aerial current is 2 amps. If the depth of modulation is reduced to 50% the aerial current becomes :-
(a) 1.7 amps (b) 1.5 amps (c) 1.414 amps (d) 1.0 amp

18. One of the disadvantages of suppressor grid modulation is that the screen dissipation of the valve must be relatively high.
(a) True (b) False

19. Cathode modulation when applied to a triode valve can be considered as a combination of anode and grid modulation.
(a) True (b) False

20. A transmitter whose unmodulated carrier power is 1000 watts is 50% modulated. What will be the unmodulated carrier power of a transmitter which when 100% modulated gives the same useful output power. By useful output power is meant power in the sidebands.
(a) 100 watts (b) 200 watts (c) 250 watts (d) 500 watts

1. The Master Oscillator of the transmitter T. 1087 is :-
   (a) A series fed Hartley Oscillator ?
   (b) A parallel fed Hartley Oscillator ?
   (c) A series fed T.A.T.G. Oscillator ?
   (d) A parallel fed T.A.T.G. Oscillator ?

2. The anode dissipation of each of the output valves of the transmitters T. 1087 and T. 1190 is :-
   (a) 100 watts (b) 150 watts (c) 250 watts (d) 500 watts

3. The anode circuit of the Power Amplifier stage of the T. 1087 is correctly tuned :-
   (a) When the D.C. feed to the stage is a minimum ?
   (b) When the P.A. neon just strikes for a given setting of bias ?
   (c) When the M.O. neon glows most brightly ?
   (d) When the P.A. anode taps are correctly chosen and the setting of the tuning condenser is exactly as shown on the calibration chart ?

4. The bias supply for the T. 1087 is obtained from a :-
   (a) half wave ?
   (b) full wave ?
   (c) bridge ?
   (d) voltage doubler circuit ?

5. For R/T purposes T. 1087 is :-
   (a) Anode modulated ?
   (b) Control grid modulated ?
   (c) Screen and anode modulated ?
   (d) Suppressor grid modulated ?

6. For C.W. operation, keying is accomplished by :-
   (a) Applying a paralysing bias to the P.A. stage whilst maintaining the M.O. in operation ?
   (b) Rendering the M.O. inoperative ?
   (c) Disconnecting the M.O. stage from the P.A. and the P.A. from the aerial ?
   (d) Switching the transmitter to operate on the space frequency ?

7. The polarising supply for the local microphone used on the R.C.P. Type 3 is obtained from :-
   (a) The same supply as the energising for the transmitter filament relay ?
   (b) The same source as the transmitter H.T. contactor ?
   (c) The 12v. D.C. supply used for remote keying ?
   (d) The rectified output of the 10v. winding of the H.T. transformer in the Remote Control Panel ?

8. In the thermal delay circuits associated with the H.T. contactor of the transmitters T. 1087 and T. 1190 two relays are used to ensure that the cathodes of the mercury vapour valves are always allowed 30 secs. to warm up.
   (a) True (b) False

9. Select the three of the following which help most to safeguard the life of the mercury vapour valves used in the power pack of the transmitters :-
   (i) The vertical mounting of the valves ?
   (ii) The use of special type horn fuses ?
   (iii) The incorporation of surge limiting choke and resistance ?
   (iv) The interlock between filament and H.T. switching ?
   (v) The space-frequency thermal delay ?
   (vi) Provision of the H.T. auto-transformer ?

10. The transmitter T. 1087 exhibits signs of 'downward modulation' when the bias of the output stage of the modulator is incorrectly adjusted so that these valves run into grid current.
   (a) True (b) False

11. For correct operation the filament relay in the Remote Control Unit Type 3 should be :-
   (a) Space biased ?
   (b) Mark biased ?
   (c) Neutrally biased ?

12. For operation of the T. 1190 on crystal fundamental, when the crystal oscillator valve employs the anode circuit of the normal doubler valve, the necessary circuit changes are most easily accomplished by removing the second valve.
   (a) True (b) False

13. If the H.T. voltmeter of the transmitters T. 1087 or T. 1190 indicates a reading of approximately 1,000 volts when the power switch is on stud one, the most probable cause is :-
   (a) One mercury vapour rectifier is unserviceable ?
   (b) A short-circuited smoothing condenser ?
   (c) The H.T. contactor is not fully closed ?
   (d) Low output voltage from the H.T. transformer ?

14. Intermittent operation of the output valves in either T. 1087 or T. 1190 is most probably due to :-
   (a) Dirty contacts on the filament relay ?
   (b) Failure of the knife switches on the door of the power pack ?
   (c) Amplifier crate not being fully inserted ?
   (d) Filament leads of the tetrodes not making good contact with the terminals on the valve crate.

15 to 20.

Complete on the duplicated slip attached to the answer pro forma the following statement. Select the appropriate phrases from those listed below.

When using the R.C.U. Type 88 and the R.C.P. Type 10 the following gives the sequence of remote C.W. operation. On putting the R.C.U. to -------- and switching on, -------- , -------- and -------- . On pressing the remote key -------- is completed and -------- is fed down the remote control lines. At the R.C.P. this -------- is -------- and -------- to a -------- the -------- of which operates -------- .

(i) metal rectifier
(ii) transmitter H.T. supply is made available
(iii) power supplies are made available for the V.T.20
(iv) D.C. output
(v) tone voltage
(vi) an additional adjustable resistance is incorporated in the common cathode line of the R/F stages of the receiver
(vii) the H.T. supply to the anode of the oscillator valve
(viii) space-biased keying relay
(ix) a 1,000 c/s voltage
(x) send
(xi) amplified
(xii) fed

1. The main layers of the Ionosphere are the Haeviside or 'E' layer and the Appleton or 'F' layer which are respectively 60 - 80 miles and 140 - 300 miles above the surface of the earth.
   (a) True (b) False

2. For communication over distances between 100 miles and 500 miles the indirect ray is used, necessitating an aerial producing high angle radiation. An appropriate aerial for this purpose would be :-
   (a) grounded quarter-wave ?
   (b) grounded half-wave ?
   (c) grounded full-wave ?
   (d) half-wave aerial half-wave above ground ?

3. A tuned parasitic element can best operate as a reflector if the spacing between the energised element and the reflector is :-
   (a) .1 wave-length ?
   (b) .25 wave-length ?
   (c) .5 wave-length ?
   (d) 1.0 wave-length ?

4. A Marconi Aerial cannot be twice as efficient as a Hertz Dipole since the earth has a definite resistance.
   (a) True (b) False

5. The ultimate aim of the designer of a remotely fed aerial is to develop a system in which standing waves are eliminated from the feeders but re-inforced on the energised radiating element.
   (a) True (b) False

6. If the current along a transmission line feeding a three-wire Rhombic Aerial is 2 Amps. then the power conveyed by the feeder is roughly :-
   (a) 160 watts (b) 320 watts (c) 1,200 watts (d) 2,400 watts

7. The range of frequencies used by a single aerial system is limited by a standing wave ratio on the feeder system of :-
   (a) 1 : 1 (b) 2 : 1 (c) 3 : 1 (d) 4 : 1

8. When adjusting a 'Y' fed dipole system, the radiating element of which has been correctly cut for resonance, the feeder currents are unbalanced. The first step in order to equalise these line currents is :-
   (a) Move the 'Y' as a whole along the aerial ?
   (b) Vary the distance between the points of attachment of the feeders always maintaining the 'Y' symmetrical with respect to the centre of the aerial ?
   (c) Adjust the length of the 'Y' ?
   (d) Vary the length of the dipole ?

9. A three-half-wavelength aerial assembled in three folds can be fed directly by :-
   (a) 50 ohm coaxial feeder ?
   (b) 80 ohm balanced twin screened feeder ?
   (c) 300 ohm line ?
   (d) 600 ohm open wire feeder ?

10. Increasing the number of colinear dipoles increases the width of the main radiation lobe of the array in the horizontal plane; increasing the number of stacked dipoles lowers the vertical angle of radiation of the major lobe of the array.
    In the above statement :*
   (a) Both parts are true ?
   (b) The first part only is correct ?
   (c) The second part only is true ?
   (d) Neither part is true ?

11. A cage aerial is flatly tuned in comparison with a simple dipole for electrically it consists of a number of tuned elements in parallel.
   (a) True (b) False

12. The output transformer of the Transmitter T. 1190 is unnecessary for either coaxial cable or open wire feeders can be connected via suitable condensers and matched to the anode circuit of the P.A. stage.
   (a) True (b) False

13. In the case of a tuned long-wire horizontal aerial the angle between the main lobe and the wire decreases as the number of the lobes increases.
   (a) True (b) False

14. A grounded quarter-wave aerial can be most conveniently fed by using :-
   (a) 50 ohm coaxial cable ?
   (b) 80 ohm screened twin cable ?
   (c) 300 ohm lines ?
   (d) 600 ohm lines ?

15 to 20.

Complete on the duplicated slip attached to the answer pro forma the following statement. Select the appropriate phrases from those listed below.

The energy -------- from -------- is rapidly attenuated. The wave -------- eventually reaches -------- from which -------- after -------- . -------- penetrate the Ionosphere to the greater extent being returned to the earth some distance from -------- . The distance between -------- and the -------- is termed the -------- .

(i) along the ground
(ii) a long wave aerial
(iii) a short wave transmitting aerial array
(iv) radiated upward
(v) one of the ionised layers
(vi) it is returned to earth
(vii) reflection
(viii) higher frequencies
(ix) lower frequencies
(x) the radiating aerial
(xi) cessation of the ground ray
(xii) first ground reflection of the sky ray
(xiii) second return of the sky ray to the ground
(xiv) skip distance
(xv) hop distance

1. For anode bend detection the valve is biased to :-
   (a) Cut-off ?
   (b) Approximately cut-off ?
   (c) Class A amplifier condition ?
   (d) Zero bias ?

2. In leaky detection, rectification takes place in the grid circuit, the grid and cathode of the valve functioning as a diode.
   (a) True (b) False

3. A suitable anode load for a R/F pentode employed as a leaky grid detector would be of the order of :-
   (a) 1,000 ohms ?
   (b) 10,000 ohms ?
   (c) 100,000 ohms ?
   (d) 1,000,000 ohms ?

4. An optimum value of R/F by-pass condenser connected to the anode of the detector valve would be :-
   (a) .1 microfarad ?
   (b) .01 microfarad ?
   (c) .001 microfarad ?
   (d) .0001 microfarad ?

5. The R/F choke used at the anode of the detector valve should have a high impedance in comparison with the reactance of the R/F by-pass condenser at audio frequencies.
   (a) True (b) False

6. The use of reaction increases the effective 'Q' of the receiver input circuit.
   (a) True (b) False

7. C.W. signals may be received by a single valve receiver provided an adequate decrease of reaction is employed and the receiver is not tuned exactly to the desired signal.
   (a) True (b) False

8. The best test that an autodyne receiver is functioning correctly, although no signal is being received, is to touch the grid of the valve when a continuous low frequency note will be heard.
   (a) True (b) False

9. The looser the degree of coupling between the aerial circuit and the grid circuit of the detector, the smaller the damping losses.
   (a) True (b) False

10. If an autodyne receiver is not functioning, although the aerial, earth and power supplies are connected, the first step would be :-
   (a) To test that there is a supply at the anode of the valve ?
   (b) To test that the valve is passing anode current ?
   (c) To test the valve for serviceability ?
   (d) To reverse the connections to the reaction coil ?

11. When a pentode valve is employed in the detector stage of a receiver the condenser between the screen and earth should have a value of approximately :-
   (a) 1 microfarad ?
   (b) .1 microfarad ?
   (c) .01 microfarad ?
   (d) .001 microfarad ?

12. The sensitivity of the leaky grid detector is higher than that of other types, but it 'loads' the tuned circuit and its signal handling capacity is limited.
   (a) True (b) False

13. The amount of regeneration in an autodyne receiver should be controllable because maximum regeneration amplification is secured when the circuit is just oscillating.
   (a) True (b) False

14. In a receiver containing a R/F stage, the phenomenon of 'pulling' can most simply be overcome by :-
   (a) Loosening the aerial coupling ?
   (b) Increasing the gain of the R/F stage ?
   (c) Decreasing the gain of the R/F stage ?
   (d) Further detuning the detector input circuit ?

15. In general the greater the selectivity of a receiver the greater the noise generated within the receiver.
   (a) True (b) False

16. Crystal type headsets have a 'flatter' frequency response curve than the magnetic type and the latter are therefore better for morse reception.
   (a) True (b) False

17. The chief advantage of using a pentode valve in the R/F stage of a receiver is :-
   (a) Prevention of self-oscillation ?
   (b) Increased gain obtainable ?
   (c) Easier control of gain ?
   (d) Greater efficiency of the valve ?

18. Standard types of valves cannot be used at frequencies higher than about 200 Mc/s even if the inductance in circuit is simply a straight wire between the valves.

(a) True (b) False

19. Speech of quality suitable for R/T purposes can be reproduced provided the receiver has a sensibly 'flat' response over a bandwidth of :-

(a) 3 Kc/s (b) 5 Kc/s (c) 7 Kc/s (d) 9 Kc/s

20. A tone control consists of a .001 microfarad condenser in series with a 250 Kilohm rheostat. Such a device :-

(a) Attenuates the high frequency response only ?
(b) Boosts the high frequency response ?
(c) Attenuates the low frequency response ?
(d) Boosts the low frequency response ?

1. When the plane of a rectangular direction finding loop is perpendicular to the direction in which a vertically polarised signal travels, then :-
   (a) The E.M.F.s induced inthe vertical members are equal and in phase ?
   (b) The E.M.F.s induced in the vertical members are equal but in antiphase ?
   (c) The E.M.F.s induced in the horizontal members are equal and in phase ?
   (d) The E.M.F.s induced in the horizontal members are equal but in antiphase ?

2. In order to combine a vertical aerial signal with a loop voltage, the former may be fed into a series resonant circuit containing L, C and R, and the output taken as :-
   (a) The voltage developed across the inductance L ?
   (b) The voltage developed across the capacity C ?
   (c) The voltage developed across either the inductance or capacity ?
   (d) The voltage developed across the resistance R ?

3. The object of screening a loop is to ensure that all parts of the loop have the same capacity to ground irrespective of the orientation of the loop and the presence of neighbouring objects.
   (a) True (b) False

4. 'Night Effect' becomes more pronounced as the distance from the transmitter increases. This is because :-
   (a) The ground wave falls off sharply with distance ?
   (b) The plane of polarisation of the sky ray tends to be rotated to a greater extent ?
   (c) The signal picked up by the loop falls off more quickly than the vertical aerial signal ?
   (d) There is increasing fading produced by the action of the ionosphere ?

5. A blurred minimum as indicated by a D/F loop may result when the quadrantal error for a particular bearing is large.
   (a) True (b) False

6. In a D/F system using crossed loops the rotation of the output coil is equivalent to rotating a loop aerial.
   (a) True (b) False

7. The accuracy of a D/F loop bearing increases as the frequency of the fixing signal is raised.
   (a) True (b) False

8. Horizontally polarised down-coming waves do not effect the function of the Adcock D/F system since the voltages induced in the horizontal members are of the same magnitude and in anti-phase.
   (a) True (b) False

9. One of the chief advantages of the Adcock D/F system is that the relationship of neighbouring objects to the aerial system remains fixed.
   (a) True (b) False

10. In Cathode Ray D/F a common R/F oscillator is used for both loop voltages and the vertical sense voltage. This is chiefly to ensure that:-
   (a) All voltages are changed to the same frequency ?
   (b) The relative phasing of the resultant waves is not changed ?
   (c) The identical characteristics of the X and Y amplifiers are not altered ?
   (d) The introduction of quadrantal error is prevented ?

11. A properly balanced and calibrated loop will give a bearing to an accuracy of :-
   (a) 1 degree (b) 2 degrees (c) 4 degrees (d) 6 degrees

12. The maximum range at which satisfactory bearings can be obtained in the daytime using signals of frequency about 500 Kc/s. is :-
   (a) 150 miles (b) 300 miles (c) 600 miles (d) 1,000 miles

13. In Radio Range crossed loops are used for the same purpose as one energised aerial and two keyed reflectors serve for S.B.A.
   (a) True (b) False

14. Bearings can always be relied upon when flying landward provided the bearings are within 15 degrees of the coastline.
   (a) True (b) False

15. Quadrantal error correction on ship-borne direction finders is normally positive in even quadrants and negative in odd quadrants.
   (a) True (b) False

16. If having set the D/F loop for 'minimum', it is then rotated through 90 degrees the signal may be either a maximum or a minimum.
   (a) True (b) False

17. V.H.F. D/F can often be unreliable due to the reflecting action of the ionosphere.
   (a) True (b) False

18. D/F equipment is usually housed in copper boxes to prevent 'antenna effect' from producing blurred minima.
   (a) True (b) False

19. Errors in D/F equipment resulting from currents induced in nearby 'open radiators' are greatly reduced by providing electrostatic screening for the aerial since this removes the effect of the induction fields of such radiators.
(a) True (b) False

20. In a D/F homing system using electronic switching, the indicator could be either a 'kicker meter' fed from the output of a switched double diode or might be a centre reading galvanometer connected across the back to back loads of the two sections of a double diode each of which is switched to an inoperative state at the same speed as the loop output is reversed.
(a) True (b) False

1. The main advantage of the superhet. receiver is :-
   (a) The heterodyne principle is employed so that signal amplification is readily effected ?
   (b) A large number of tuned circuits is available ?
   (c) Automatic volume control can be used ?
   (d) Optimum use can be made of diode detection ?

2. Linear detection is used at the first detector or mixer of a superhet. receiver and to avoid distortion the oscillator voltage is arranged to be large relative to the signal voltage.
   (a) True (b) False

3. For optimum operation of a triode hexode frequency changer the hexode section should be biased practically to cut-off and the amplitude of oscillations, such that the oscillator grid is driven slightly positive.
   (a) True (b) False

4. Residual coupling between oscillator and signal sections of multi-electrode frequency changers prevent their use at frequencies above 20 Mc/s.
   (a) True (b) False

5. (i) Regeneration decreases the effective resistance of the tuned circuit and leads to sideband cutting.
   (ii) Practical adjustment for optimum regeneration requires a measure of skill.
   (iii) The setting of the regeneration control will be different for different signal frequencies.
   (iv) Due to improper adjustment a regenerative detector can be so unstable that it will heterodyne with any signal to produce annoying squeals.
   The above statements are :-
   (a) All true (b) three true (c) Two true (d) One true

6. Conditions for optimum adjacent and second channel selectivity are satisfied if a medium intermediate frequency i.e. 450 Kc/s. is chosen for broadcast purposes.
   (a) True (b) False

7. Distortion at the diode detector may be avoided by using :-
   (i) A diode load at least 20 times the impedance of the valve.
   (ii) Small signals only.
   (iii) A load capacity such that its reactance at the highest speech frequency is at least 60% of the load resistance.
   These statements are :-
   (a) All true (b) Two true (c) One true (d) None true

8. In aligning a superhet. receiver the first step should be to :-
   (a) Check the tuning of the I/F circuits nearest the detector ?
   (b) Check the tuning of the I/F circuits nearest the mixer ?
   (c) Adjust the oscillator alignment ?
   (d) Adjust the alignment of the R/F circuits ?

9. The oscillator circuits of a superhet. are normally provided with both 'padders' and 'trimmers'. The former, series condensers, are used for tracking at the high end of each frequency band.
   (a) True (b) False

10. In a R/T superhet. the coupling between primary and secondary circuits of the I/F transformers is :-
   (a) Very loose ?
   (b) Slightly less than critical value ?
   (c) Slightly more than critical value ?
   (d) Very tight ?

11. It is usual to have a slightly higher degree of coupling in the last I/F transformer than in previous transformers to compensate for the loss of gain and selectivity in the secondary circuit.
   (a) True (b) False

12. The I/F of a superhet. is 490 Kc/s. A filter consisting of a 50 micro-microfarad condenser is used in conjunction with an inductance to suppress interference at I/F. The value of the inductance will be :-
   (a) 20 millihenries ?
   (b) 2 millihenries ?
   (c) 200 microhenries ?
   (d) 20 microhenries ?

13. The amount of Cross-Talk between two stations of frequency both considerably different from that of the desired signal will :-
   (i) Depend on the magnitude of the interfering signals.
   (ii) Be non-existent unless the first R/F stage is operating under non-linear conditions.
   (iii) Will depend on the amplitude of the desired signal.
   (iv) Be non-existent if the input circuit of the R/F stage is fairly selective.

   The above statements are :-
   (a) All true (b) Three true (c) Two true (d) One true

14. Hum from rectifier ripple is more unpleasant when a push-pull amplifier rather than a single final stage is used.
   (a) True (b) False

15. Where a noise limiter is used in a superhet. the output of a separate I/F amplifier is rectified and applied as positive bias to the final I/F stage.
   (a) True (b) False

16. In high fidelity superhet. receivers the tuning indicator is operated from a separate circuit.
   (a) True (b) False

17. The best procedure when using a R/T C.W. superhet. receiver for the reception of C.W. is that the A.V.C. should be switched out and a manual gain control employed.
   (a) True (b) False

18. In a superhet. receiver employing a crystal filter the output is a maximum when the frequency of the I/F signal is the frequency for which the crystal is series resonant.
   (a) True (b) False

19. Frequency diversity depends on the fact that :-
   (a) Signals of certain wavelengths suffer a change in frequency on reflection at the ionosphere of only a few hundred cycles ?
   (b) Short-wave signals arrive at certain preferred angles that are relatively stable over an appreciable time interval ?
   (c) Signals induced in antennae some five to ten wavelengths apart fade independently ?
   (d) Signals of frequency differing by only some 100 cycles tend to fade independently ?

20. In triple diversity reception for R/T operation three receivers are employed, each with its own square law detector and the combined outputs are fed to a single A.V.C. stage controlling all three receivers.
   (a) True (b) False

APPENDIX G.

Progress Test No. Course No.

Instructions for answering Progress Tests.

1. The questions to be answered have four suggested answers only ONE of the answers is correct, unless otherwise stated.
2. Answer the questions by STRIKING OUT the letters which are INCORRECT on the answer sheet below.
3. Marks will be allotted as follows :-
   One mark for each correct answer.
   One mark deducted for each incorrect answer.
   Thus do not guess or you will be penalised.

ANSWER SHEET.

For official use only.

Question number.					Right	Wrong	Remarks
1.	(a)	(b)	(c)	(d)			
2.	(a)	(b)	(c)	(d)			
3.	(a)	(b)	(c)	(d)			
4.	(a)	(b)	(c)	(d)			
5.	(a)	(b)	(c)	(d)			
6.	(a)	(b)	(c)	(d)			
7.	(a)	(b)	(c)	(d)			
8.	(a)	(b)	(c)	(d)			
9.	(a)	(b)	(c)	(d)			
10.	(a)	(b)	(c)	(d)			
11.	(a)	(b)	(c)	(d)			
12.	(a)	(b)	(c)	(d)			
13.	(a)	(b)	(c)	(d)			
14.	(a)	(b)	(c)	(d)			
15.	(a)	(b)	(c)	(d)			
16.	(a)	(b)	(c)	(d)			
17.	(a)	(b)	(c)	(d)			
18.	(a)	(b)	(c)	(d)			
19.	(a)	(b)	(c)	(d)			
20.	(a)	(b)	(c)	(d)			

Totals.

Final Mark .

APPENDIX H.

ANALYSIS OF PROGRESS TESTS ONE AND TWO.

No. of Test.	No. of Pupil Questions.	Solutions. Right	Wrong	Unanswered	%age Wrong/Right
P.T.1 (l_1)	720	530	43	147	8.11%
P.T.1 (l_2)	720	458	37	225	7.93%
P.T.1 (m_1)	380	257	31	92	12.10%
P.T.1 (m_2)	380	261	29	90	11.11%
P.T.1 (n_1)	320	186	20	114	10.75%
P.T.1 (n_2)	320	166	22	132	13.25%
P.T.1 (o_1)	360	238	17	105	7.14%
P.T.1 (o_2)	360	193	16	151	8.29%
P.T.1 (p_1)	260	178	10	72	5.62%
P.T.1 (p_2)	260	171	19	70	11.11%
P.T.2 (l_1)	720	526	38	156	7.22%
P.T.2 (l_2)	720	413	30	277	7.26%
P.T.2 (m_1)	380	243	27	110	11.32%
P.T.2 (m_2)	380	217	18	145	8.29%
P.T.2 (n_1)	320	149	20	151	13.42%
P.T.2 (n_2)	320	139	10	171	7.19%
P.T.2 (o_1)	360	183	17	160	9.29%
P.T.2 (o_2)	360	132	20	208	15.15%
P.T.2 (p_1)	260	175	14	71	8.00%
P.T.2 (p_2)	260	163	8	89	4.91%
TOTALS	8160	4978	446	2736	8.96%

APPENDIX I.

Summary of Progress Tests Results Group 1_1 .

Pupil Number	Test Number J	1	2	3	4	5	6	7
1.	73	19	19	19	20	19	18	20
2.	63	15	16	16	13	17	15	14
3.	62	18	14	15	14	15	11	17
4.	72	19	17	17	19	20	16	18
5.	60	13	12	12	13	14	13	12
6.	61	17	15	17	17	16	13	10
7.	71	20	18	16	15	18	17	19
8.	59	8	8	12	15	14	10	13
9.	59	12	10	14	16	12	12	12
10.	61	13	16	15	12	13	10	11
11.	65	16	14	15	14	17	14	20
12.	58	14	9	9	9	13	11	10
13.	65	15	17	10	12	17	16	15
14.	62	13	13	15	15	16	11	13
15.	70	13	16	17	16	15	15	17
16.	58	12	8	13	7	10	12	15
17.	66	16	16	14	13	17	14	14
18.	60	11	13	13	15	16	12	17
19.	66	15	16	14	12	16	14	15
20.	62	15	12	14	13	16	12	16
21.	60	10	14	12	15	15	13	13
22.	60	7	15	15	17	17	14	18
23.	63	14	15	15	10	17	11	13
24.	71	15	15	18	17	16	15	16
25.	65	16	16	12	17	18	13	15
26.	76	20	20	20	19	20	20	18
27.	71	17	18	16	18	20	17	15
28.	62	14	12	16	12	15	15	15
29.	70	16	18	19	17	19	13	16
30.	62	14	11	10	13	14	12	12
31.	66	14	13	16	15	17	13	11
32.	63	15	15	16	11	16	14	15
33.	65	15	15	16	14	16	12	10
34.	71	18	16	17	17	17	14	18
35.	66	15	17	16	16	18	13	15
36.	67	16	17	15	17	17	15	10
Totals	2331	530	526	536	525	583	490	528
Means	64.75	14.72	14.61	14.89	14.58	16.19	13.61	14.67

Summary of Progress Tests Results Group 1_1 .

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	15	15	14	18	13	18	14	13
2.	15	13	9	13	11	15	10	12
3.	12	12	10	15	10	10	13	12
4.	16	15	12	15	14	17	16	15
5.	12	10	10	12	11	15	12	9
6.	11	12	11	13	10	10	9	10
7.	17	13	14	19	13	13	16	15
8.	10	8	8	11	9	11	10	11
9.	11	9	6	12	7	10	8	10
10.	9	10	9	10	11	14	13	9
11.	15	11	9	14	11	13	12	12
12.	9	6	5	13	8	8	9	9
13.	13	12	9	12	8	14	8	10
14.	12	12	9	12	10	9	12	12
15.	13	13	13	15	14	12	15	15
16.	11	9	9	8	12	12	12	7
17.	14	10	10	12	11	13	13	11
18.	13	11	12	11	10	11	9	10
19.	13	11	11	14	13	13	16	14
20.	11	7	10	14	11	14	10	9
21.	11	9	9	12	10	12	11	12
22.	10	6	6	11	9	9	10	12
23.	12	11	7	12	10	13	12	12
24.	14	13	10	16	15	16	17	14
25.	9	9	12	16	14	14	13	13
26.	19	17	16	17	14	20	17	19
27.	15	15	15	15	16	16	17	15
28.	13	11	9	13	7	12	9	10
29.	15	12	12	16	14	17	14	13
30.	10	7	6	14	10	14	11	11
31.	11	13	12	16	13	16	13	12
32.	13	10	8	13	10	13	14	11
33.	11	13	13	14	16	14	15	10
34.	16	13	11	13	11	15	13	13
35.	12	11	11	15	7	13	9	11
36.	14	11	10	15	13	15	14	14
Totals	457	400	367	491	406	481	446	427
Means	12.69	11.11	10.20	13.64	11.30	13.36	12.40	11.86

Summary of Progress Tests Results Group 1_2 .

Pupil Number	J	1	2	3	4	5	6	7
				Test Number				
1.	61	12	11	16	12	9	13	10
2.	69	12	12	14	14	20	13	15
3.	72	17	15	15	18	17	16	15
4.	72	18	17	16	16	16	15	16
5.	59	11	12	10	8	12	8	12
6.	64	13	10	10	13	18	14	15
7.	50	8	5	6	8	6	5	8
8.	60	12	9	11	10	11	11	12
9.	62	13	12	11	10	12	14	10
10.	59	10	12	12	10	10	9	9
11.	67	13	11	14	16	19	14	15
12.	76	20	19	17	16	20	18	20
13.	63	11	9	13	12	14	12	14
14.	57	10	9	8	10	9	6	9
15.	60	11	10	12	12	11	9	9
16.	62	10	7	11	10	9	12	11
17.	61	11	9	12	8	10	10	12
18.	57	10	10	9	12	9	8	11
19.	66	15	10	13	11	14	13	14
20.	67	14	13	12	14	15	12	16
21.	65	12	11	12	12	17	14	17
22.	62	14	13	10	14	13	11	13
23.	51	5	6	8	7	8	8	10
24.	60	14	7	11	10	10	10	10
25.	69.	14	14	15	14	18	17	13
26.	63.	12	12	12	13	12	10	11
27.	64	12	13	12	12	17	15	14
28.	75	19	18	16	18	18	17	19
29.	70	13	15	15	15	18	13	19
30.	55	11	9	9	8	7	9	7
31.	64	12	15	10	12	18	13	14
32.	50	6	4	7	5	6	7	6
33.	72	20	16	16	15	16	15	13
34.	63	12	12	15	10	14	12	16
35.	63	17	13	13	12	15	13	16
36.	65	14	13	15	14	15	12	13
Totals	2275	458	413	438	431	483	428	464
Means	63.20	12.72	11.47	12.17	11.97	13.43	11.89	12.89

Summary of Progress Tests Results Group 1_2.

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	13	11	15	12	13	12	14	11
2.	14	14	15	17	14	17	16	12
3.	19	17	14	16	20	18	19	18
4.	17	18	16	17	15	16	17	17
5.	15	11	11	12	16	14	13	12
6.	14	13	10	14	12	16	12	14
7.	11	6	10	8	8	10	9	9
8.	12	12	15	12	9	15	10	12
9.	15	13	10	12	12	13	14	12
10.	11	11	11	10	12	15	14	9
11.	17	13	11	15	10	16	13	16
12.	20	18	18	20	16	20	15	20
13.	14	13	13	13	14	12	13	14
14.	10	10	11	10	11	12	13	8
15.	13	11	14	13	12	14	13	10
16.	14	14	12	13	10	15	11	12
17.	14	9	12	14	14	14	13	10
18.	13	10	8	11	14	13	16	9
19.	15	12	15	16	15	16	15	15
20.	18	16	10	14	13	18	17	18
21.	17	15	15	13	15	17	12	16
22.	17	12	3	13	14	16	16	16
23.	10	9	8	9	7	10	7	10
24.	13	12	10	13	11	12	11	10
25.	18	18	15	14	17	18	20	16
26.	15	13	12	13	14	12	16	13
27.	16	15	16	9	11	17	10	15
28.	19	18	17	18	13	19	15	18
29.	17	15	16	15	17	17	20	16
30.	9	7	6	9	12	10	10	8
31.	11	15	11	14	14	17	15	13
32.	7	7	5	10	7	8	11	6
33.	20	12	10	19	16	20	18	17
34.	15	11	11	14	15	16	17	14
35.	17	8	15	14	13	16	15	13
36.	16	15	13	12	12	16	14	12
Totals	526	454	434	478	468	537	504	471
Means	14.61	12.61	12.06	13.28	13.00	14.92	14.00	13.08

Summary of Progress Tests Results Group m_1 .

Pupil Number	Test Number J	1	2	3	4	5	6	7
1.	67	16	14	12	16	16	13	15
2.	74	18	17	17	20	19	17	19
3.	61	11	12	9	14	14	12	11
4.	54	17	6	8	9	12	10	8
5.	55	10	9	14	12	10	9	12
6.	62	11	15	11	12	16	13	14
7.	69	12	14	15	16	15	14	16
8.	58	10	11	10	13	14	11	16
9.	58	11	12	9	9	13	12	13
10.	52	8	7	10	10	9	8	7
11.	62	11	7	13	15	13	12	13
12.	55	10	8	9	12	12	11	14
13.	71	16	15	16	17	17	17	20
14.	78	18	18	20	20	20	20	18
15.	71	18	16	15	18	18	16	15
16.	69	13	16	14	17	17	15	18
17.	78	20	20	19	19	20	18	20
18.	67	14	12	14	15	19	17	18
19.	71	13	14	15	17	19	16	20
Totals	1232	257	243	250	281	293	271	287
Means	64.84	13.53	12.79	13.16	14.74	15.42	14.43	15.11

Summary of Progress Tests Results Group m_1.

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	14	13	10	13	11	14	12	13
2.	16	14	13	16	12	16	15	14
3.	12	9	10	11	12	11	10	8
4.	8	7	5	8	6	9	8	6
5.	11	7	5	8	8	8	9	8
6.	9	8	8	12	7	9	11	9
7.	14	13	14	14	15	15	13	13
8.	10	9	7	11	8	10	10	11
9.	10	8	7	10	8	10	9	7
10.	7	5	5	7	6	6	7	5
11.	11	11	9	8	13	13	12	9
12.	8	6	6	9	9	8	8	9
13.	15	14	11	14	10	15	14	11
14.	18	16	15	17	18	18	17	17
15.	15	13	12	16	13	16	13	13
16.	13	12	11	14	12	13	13	12
17.	18	17	16	19	14	19	17	15
18.	12	12	11	15	11	15	12	11
19.	13	14	12	15	13	15	15	12
Totals	234	208	187	239	206	240	225	203
Means	12.32	10.95	9.84	12.58	10.84	12.63	11.84	10.68

Summary of Progress Tests Results Group m_2 .

Pupil Number	Test Number J	1	2	3	4	5	6	7
1.	66	17	11	10	13	10	10	10
2.	76	18	16	13	17	18	15	17
3.	59	12	7	9	9	10	8	11
4.	79	20	17	17	19	20	18	19
5.	65	10	12	11	12	12	12	13
6.	52	4	6	7	7	9	5	6
7.	74	17	14	14	13	16	13	12
8.	77	18	16	16	15	16	14	17
9.	75	14	13	15	16	17	14	13
10.	58	10	10	9	9	12	8	7
11.	65	13	10	10	12	12	12	14
12.	64	12	10	10	12	9	10	12
13.	63	12	9	10	11	14	10	10
14.	65	13	8	10	12	14	13	14
15.	74	16	14	14	16	15	10	15
16.	63	14	9	11	12	11	11	9
17.	68	12	11	12	13	13	13	15
18.	68	13	11	12	16	15	12	16
19.	73	16	13	12	17	17	13	11
Totals	1284	261	217	222	251	260	221	241
Means	67.58	13,74	11.42	11.68	13.21	13.68	11.63	12.68

Summary of Progress Tests Results Group m_2 .

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	17	11	12	12	14	12	12	13
2.	19	18	16	15	18	19	17	16
3.	12	10	5	10	8	12	13	6
4.	20	18	19	19	20	20	18	19
5.	18	13	13	16	15	15	13	16
6.	7	6	7	7	8	8	7	6
7.	16	12	13	15	15	14	19	15
8.	19	16	17	17	18	18	20	15
9.	19	15	18	17	17	17	18	17
10.	9	9	6	9	9	11	11	9
11.	16	13	11	9	12	15	13	14
12.	16	12	7	13	10	14	14	14
13.	12	13	9	10	13	15	14	10
14.	12	13	10	13	12	14	11	11
15.	20	15	11	16	15	17	14	16
16.	14	12	9	12	12	14	12	12
17.	14	14	13	16	13	14	14	16
18.	18	15	16	11	15	15	15	11
19.	15	16	12	15	17	18	18	13
Totals	293	251	224	252	261	282	273	249
Means	15.42	13.21	11,79	13.26	13.74	14.84	14.37	13.11

Summary of Progress Tests Results Group n_1.

Pupil Number	J	1	2	3	4	5	6	7
				Test Number				
1.	61	10	9	9	14	12	10	13
2.	68	8	9	10	13	13	12	14
3.	54	8	4	5	9	8	7	10
4.	50	4	3	4	7	7	5	4
5.	66	12	8	11	13	13	12	11
6.	56	9	10	7	10	9	8	12
7.	74	14	13	13	18	15	15	14
8.	72	12	10	14	16	16	14	13
9.	65	9	4	8	8	9	8	6
10.	56	12	5	7	9	10	10	9
11.	81	19	19	18	20	20	19	18
12.	69	14	9	11	14	15	13	13
13.	69	12	12	11	16	14	15	15
14.	76	17	15	14	16	18	17	20
15.	66	12	12	9	9	11	10	8
16.	51	14	7	10	10	11	8	9
Totals	1034	186	149	161	202	201	183	189
Means	64.62	11.62	9.31	10.06	12.63	12.56	11.44	11.81

Summary of Progress Tests Results Group n_1 .

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	9	10	8	9	10	12	12	8
2.	13	10	10	13	12	12	11	11
3.	6	5	5	6	10	6	9	5
4.	5	3	4	4	7	4	5	4
5.	15	10	11	12	8	13	9	10
6.	6	7	5	6	8	9	7	5
7.	15	13	13	14	14	15	13	13
8.	13	12	12	12	12	13	14	12
9.	9	9	6	8	6	10	6	8
10.	8	6	7	7	8	7	10	7
11.	19	19	16	18	15	20	18	18
12.	15	14	10	15	11	15	10	13
13.	14	10	11	13	8	11	11	13
14.	17	13	14	16	12	16	14	17
15.	10	8	10	11	9	9	8	11
16.	5	9	8	10	9	10	8	10
Totals	179	158	150	174	159	182	165	165
Means	11.19	9.88	9.38	10.88	9.94	11.38	10.31	10.31

Summary of Progress Tests Results Group n_2 .

Pupil Number	Test Number J	1	2	3	4	5	6	7
1.	69	10	10	11	15	13	12	9
2.	73	12	13	14	14	14	12	17
3.	66	11	8	7	11	10	7	10
4.	67	10	8	9	11	9	8	11
5.	73	9	9	10	16	11	13	14
6.	75	12	14	11	18	16	14	20
7.	64	12	7	10	10	12	13	11
8.	69	10	7	9	11	12	10	12
9.	60	8	6	8	9	6	9	9
10.	59	10	6	12	8	5	8	5
11.	60	9	8	7	10	9	7	10
12.	55	7	4	5	6	4	5	4
13.	68	11	6	7	9	12	12	14
14.	77	14	15	14	16	15	18	19
15.	67	10	7	8	12	11	9	8
16.	68	11	11	8	14	14	12	11
Totals	1070	166	139	150	190	173	169	184
Means	66.88	10.38	8.69	9.38	11.88	10.81	10.56	11.50

Summary of Progress Tests Results Group n_2 .

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	13	12	10	13	9	14	10	12
2.	13	12	11	15	12	14	12	12
3.	12	9	10	11	10	10	9	12
4.	10	9	9	10	11	10	13	11
5.	15	14	13	14	14	13	14	14
6.	16	15	13	15	12	18	13	15
7.	13	12	10	12	9	13	10	12
8.	12	13	11	12	13	13	14	11
9.	8	6	10	9	10	11	7	7
10.	11	6	9	7	9	7	11	6
11.	7	9	8	10	7	7	8	10
12.	6	6	7	6	4	7	6	7
13.	12	13	10	11	12	15	10	10
14.	19	17	14	18	15	18	16	20
15.	11	11	7	12	10	12	7	10
16.	12	12	11	12	12	13	11	12
Totals	190	176	163	187	169	195	171	181
Means	11.88	11.00	10.19	11.69	10.56	12.19	10.69	11.31

Summary of Progress Tests Results Group o_1 .

Pupil Number	Test Number J	1	2	3	4	5	6	7
1.	55	8	5	6	10	9	5	6
2.	62	13	9	11	15	14	10	10
3.	77	19	18	16	20	18	13	20
4.	50	6	4	5	7	7	4	3
5.	63	11	11	12	9	12	10	12
6.	75	19	17	16	18	15	16	17
7.	71	17	13	16	17	17	15	14
8.	73	16	13	13	16	16	14	16
9.	77	20	14	18	19	20	18	19
10.	57	13	8	9	10	11	9	10
11.	58	11	8	10	13	11	8	9
12.	56	12	7	8	8	6	6	7
13.	68	14	11	13	15	16	13	16
14.	69	15	10	15	17	18	10	13
15.	62	10	9	8	12	13	8	9
16.	70	15	12	14	14	15	15	17
17.	53	8	6	8	8	10	9	5
18.	55	11	8	9	9	14	7	10
Totals	1151	238	183	207	237	241	190	213
Means	63.95	13.24	10.17	11.50	13.17	13.28	10.56	11.83

Summary of Progress Tests Results Group o_1.

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	7	7	4	7	6	10	8	6
2.	11	10	6	12	8	13	11	12
3.	16	16	13	15	14	16	15	18
4.	5	2	4	4	5	5	5	4
5.	8	9	10	10	11	11	12	9
6.	14	14	15	15	16	14	14	13
7.	16	11	10	16	9	14	16	10
8.	14	12	10	13	9	15	14	12
9.	17	13	14	17	15	18	16	12
10.	9	6	7	8	8	8	8	8
11.	9	6	5	11	9	8	12	10
12.	8	4	4	7	5	7	8	9
13.	10	10	7	10	7	12	9	11
14.	12	12	9	13	10	15	12	9
15.	10	6	8	9	9	9	11	8
16.	12	13	12	12	14	16	12	12
17.	7	3	8	6	11	6	9	8
18.	6	5	3	8	4	6	6	5
Totals	191	159	149	193	170	203	198	176
Means	10.61	8.83	8.28	10.72	~~8.33~~ 9.44	11.28	11.00	9.78

Summary of Progress Tests Results Group o_2.

Pupil Number	Test Number J	1	2	3	4	5	6	7
1.	61	9	9	8	10	7	10	10
2.	56	6	7	11	9	7	7	12
3.	69	14	15	12	14	19	12	11
4.	60	10	4	8	9	8	10	8
5.	68	15	9	9	10	11	11	10
6.	64	10	7	8	10	10	12	16
7.	57	9	4	10	10	6	6	8
8.	69	13	12	10	15	16	16	12
9.	64	14	7	10	10	14	9	14
10.	65	17	8	13	14	12	10	12
11.	54	8	5	5	9	6	5	6
12.	56	12	9	6	11	12	8	11
13.	58	8	5	7	7	9	9	11
14.	66	11	6	9	12	10	12	15
15.	49	4	3	3	5	4	4	5
16.	64	10	9	7	12	12	12	12
17.	69	12	8	11	13	15	14	14
18.	63	11	5	11	8	10	8	16
Totals	1112	193	132	158	188	190	175	203
Means	61.77	10.72	7.33	8.78	10.44	10.55	9.72	11.28

Summary of Progress Tests Results Group O_2 .

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	11	8	10	11	9	14	12	9
2.	11	7	7	12	9	11	11	6
3.	13	12	12	17	12	15	12	10
4.	12	10	8	13	11	12	10	10
5.	15	10	12	14	10	13	12	12
6.	14	13	13	14	12	12	12	12
7.	7	8	8	9	8	10	7	7
8.	13	12	14	14	13	15	14	14
9.	10	10	9	13	10	15	14	9
10.	13	10	11	11	9	14	10	13
11.	8	7	7	8	5	9	10	8
12.	8	13	11	7	13	9	13	16
13.	11	8	9	10	9	12	11	10
14.	13	12	13	15	12	14	13	12
15.	6	4	6	5	9	7	8	8
16.	14	8	10	12	10	12	10	14
17.	18	14	10	13	10	18	17	14
18.	11	6	13	10	12	10	12	11
Totals	208	172	183	208	183	222	208	195
Means	11.55	9.55	10.17	11.55	10.17	12.33	11.55	10.83

Summary of Progress Tests Results Group p_1.

Pupil Number	Test Number J	1	2	3	4	5	6	7
1.	59	15	13	12	12	14	14	15
2.	67	16	17	14	15	15	17	14
3.	73	20	20	19	18	20	18	19
4.	65	16	15	16	12	13	14	13
5.	69	17	16	15	16	19	15	18
6.	65	13	12	12	12	16	15	16
7.	49	7	10	10	8	11	9	8
8.	63	15	15	14	13	15	13	13
9.	70	18	18	20	20	16	17	19
10.	45	4	7	5	7	10	9	7
11.	53	11	9	7	10	13	12	11
12.	69	16	15	18	17	16	16	15
13.	53	10	8	9	11	12	11	14
Totals	800	178	175	171	171	190	180	182
Means	61.54	13.69	13.46	13.15	13.15	14.62	13.85	14.00

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	11	9	8	10	9	11	10	9
2.	12	13	12	12	12	15	15	11
3.	18	17	14	17	13	18	18	16
4.	14	12	11	14	11	11	14	13
5.	13	13	11	16	15	16	16	13
6.	14	8	9	16	10	14	11	12
7.	7	5	6	6	8	8	9	7
8.	12	14	10	13	12	16	14	11
9.	15	11	12	16	15	13	16	14
10.	5	5	7	3	5	7	3	4
11.	8	8	6	8	7	8	8	8
12.	14	11	13	15	12	13	13	12
13.	9	6	5	9	6	10	8	7
Totals	152	132	124	155	135	160	155	137
Means	11.70	10.15	9.54	11.92	10.38	12.31	11.92	10.54

Summary of Progress Tests Results Group p_2 .

Pupil Number	Test Number J	1	2	3	4	5	6	7
1.	70	16	18	15	17	16	13	14
2.	74	19	17	16	18	16	16	17
3.	55	10	8	7	8	11	6	9
4.	59	13	12	13	9	12	11	15
5.	59	10	10	11	10	13	9	11
6.	79	20	20	19	19	20	20	20
7.	46	5	6	6	5	8	5	4
8.	58	11	9	14	9	11	8	7
9.	57	9	10	10	9	12	10	12
10.	56	10	10	9	11	9	9	11
11.	70	15	12	11	14	15	12	12
12.	71	17	15	15	15	15	10	13
13.	74	16	16	16	17	18	13	14
Totals	828	171	163	162	161	176	142	159
Means	63.70	13.16	12.54	12.46	12.37	13.54	10.92	12.23

Pupil Number	Test Number 8	9	10	11	12	13	14	15
1.	15	16	12	16	11	18	16	13
2.	19	18	17	17	16	19	18	15
3.	12	8	7	8	9	10	9	9
4.	15	13	6	12	7	14	9	10
5.	14	12	10	10	9	14	12	12
6.	20	19	19	20	17	20	20	18
7.	8	5	6	4	8	6	8	6
8.	14	11	12	11	14	11	15	12
9.	13	10	10	9	9	13	11	9
10.	13	10	9	11	11	12	12	10
11.	15	14	13	15	14	15	14	12
12.	17	15	15	17	16	17	15	15
13.	18	16	14	14	13	17	16	13
Totals	193	167	150	164	154	186	175	154
Means	14.85	12.85	11.54	12.62	11.85	14.31	13.46	11.85

APPENDIX J.

Correlation between initial and re-tested scores (Jenkins')

Class 1.

	X_1	X_2	x_1		x_2		x_1x_2		x_1^2	x_2^2
1.	63	67		-2	2			-4	4	4
2.	62	60		-3		-5	15		9	25
3.	72	73	7		8		56		21	64
4.	59	62		-6		-3	18		36	9
5.	61	61		-4		-4	16		16	16
6.	65	59		0		-6	0			36
7.	58	62		-7		-3	21		49	9
8.	60	63		-5		-2	10		25	4
9.	66	67	1		2		2		1	4
10.	62	58		-3		-7	21		9	49
11.	60	63		-5		-2	10		25	4
12.	71	69	6		4		24		36	16
13.	76	79	11		14		154		121	196
14.	62	65		-3		0	0		9	0
15.	63	66		-2	1			-2	4	1
16.	71	73	6		8		48		36	64
17.	66	62	1			-3		-3	1	9
18.	67	67	2		2		4		4	4
19.	58	60		-7		-5	35		49	25
			34	− 47	41	− 40	434	− 9	455	539
			−13		1		425			

$$\frac{\Sigma x_1}{N} = \frac{-13}{19} \qquad \frac{\Sigma x_2}{N} = \frac{1}{19}$$

$$\left(\frac{\Sigma x_1}{N}\right)^2 = \cdot 47 \qquad \left(\frac{\Sigma x_2}{N}\right)^2 = 0 \qquad \left(\frac{\Sigma x_1}{N}\right)\left(\frac{\Sigma x_2}{N}\right) = -\cdot 04$$

$$\frac{\Sigma x_1^2}{N} = 23\cdot 95 \qquad \frac{\Sigma x_2^2}{N} = 28\cdot 37 \qquad \frac{\Sigma x_1 x_2}{N} = 22\cdot 37$$

$$r = \frac{\frac{\Sigma x_1 x_2}{N} - \frac{\Sigma x_1}{N} \cdot \frac{\Sigma x_2}{N}}{\sqrt{\frac{\Sigma x_1^2}{N} - \left(\frac{\Sigma x_1}{N}\right)^2} \cdot \sqrt{\frac{\Sigma x_2^2}{N} - \left(\frac{\Sigma x_2}{N}\right)^2}}$$

$$= \cdot 86$$

Correlation between initial and re-tested scores (Jenkins')

Class 2.

	X_1	X_2	x_1		x_2		x_1x_2	x_1^2	x_2^2
1.	66	68	1		3		3	1	9
2.	76	73	11		8		88	121	64
3.	59	60		-6		-5	30	36	25
4.	79	76	14		11		154	196	121
5.	65	65	0		0		0	0	0
6.	52	54		-7		-11	77	49	121
7.	74	76	9		11		99	81	121
8.	77	79	12		14		168	144	196
9.	75	77	10		12		120	100	144
10.	58	60		-7		-5	35	49	25
11.	65	67	0		2		2	0	4
12.	64	62		-1		-3	3	1	9
13.	63	61		-2		-4	8	4	16
14.	65	60	0			-5	0	0	25
15.	74	72	9		7		63	81	49
16.	63	61		-2		-4	8	4	16
17.	68	65	3		0		0	9	0
18.	68	67	3		2		6	9	4
19.	73	70	8		5		40	64	25
			80	— 25	75	— 37	904	949	974
			55		38				

r = .96

Correlation between initial and re-tested scores (Jenkins')

<u>Class 3.</u>

	X_1	X_2	x_1		x_2		$x_1 x_2$		x_1^2	x_2^2
1.	61	63		-4		-2	8		16	4
2.	68	70	3		5		15		9	25
3.	54	50		-11		-15	165		121	225
4.	50	50		-15		-15	225		225	225
5.	66	63	1			-2		-2	1	4
6.	56	59		-9		-6	54		81	36
7.	74	77	9		12		108		81	144
8.	72	68	7		3		21		49	9
9.	55	57		-10		-8	88		100	64
10.	56	60		-9		-5	45		81	25
11.	81	82	16		17		272		256	289
12.	69	70	4		5		20		16	25
13.	69	65	4		0		0		16	0
14.	76	72	11		7		77		121	49
15.	66	69	1		4		4		1	16
16.	51	55		-14		-10	140		196	100
			56	-72	53	-63	1242	-2	1370	1240
			-16		-10		1240			

$r = .95$

COrrelation between initial and re-tested scores (Jenkins') .

Class 4.

	X_1	X_2	x_1		x_2		x_1x_2	x_1^2	x_2^2
1.	59	62		-6		-3	18	36	9
2.	67	73	2		8		16	4	64
3.	73	71	8		6		48	64	36
4.	65	68	0		3		0	0	9
5.	69	73	4		8		32	16	64
6.	65	68	0		3		0	0	9
7.	49	55		-16		-10	160	256	100
8.	63	61		-2		-4	8	4	16
9.	70	74	5		9		45	25	81
10.	45	49		-20		-16	320	400	256
11.	53	56		-12		-9	108.	144	81
12.	69	67	4		2		8	16	4
13.	53	57		-12		-8	96	144	64
			23	-68	39	-50	859	1109	793
			-45		-11				

r = .95

Class 5.

	X_1	X_2	x_1		x_2		x_1x_2	x_1^2	x_2^2
1.	70	73	5		8		40	25	64
2.	74	70	9		5		45	81	25
3.	55	58		-10		-7	70	100	49
4.	59	63		-6		-2	12	36	4
5.	59	61		-6		-4	24	36	16
6.	79	77	14		12		168	196	144
7.	46	49		-19		-16	304	361	256
8.	58	62		-7		-3	21	49	9
9.	57	55		-8		-10	80	64	100
10.	56	60		-9		-5	45	81	25
11.	70	67	5		2		10	25	4
12.	71	75	6		10		60	36	100
13.	74	77	9		12		108	81	144
			48	-65	49	-47	987	1171	940
			-17		2				

r = .95

APPENDIX K.

Analysis of the Combined Results of Progress Test 1.

The group total scores for the initial test (Jenkins' Test) and the final achievement test (Progress Test 1) are tabulated below :-

	METHOD 1		METHOD 2		INSTRUCTOR-GROUPS		No. of cases in each Instr.-group.
	Initial	Final	Initial	Final	Initial	Final	
Instructor 1	2331	530	2275	458	4606	988	72
Instructor m	1232	257	1284	261	2516	518	38
Instructor n	1034	186	1070	166	2104	352	32
Instructor o	1151	238	1112	193	2263	431	36
Instructor p	800	178	828	171	1628	349	26
Totals	6548	1389	6569	1249	13117	2638	204

(a). The first major step in the calculations was to determine for the initial scores (i) the sum of squares between methods (ii) the sum of squares between instructor-groups, and finally (iii) the sum of squares between classes. Since the sum of squares between classes is equal to the sum of squares between methods plus the sum of squares between groups and the interaction (methods by groups) the latter term could then be obtained by subtraction.

Sum of squares between methods

$$= \frac{(6548)^2}{102} + \frac{(6569)^2}{102} - \frac{(13117)^2}{204}$$

$= 3.0$

Sum of squares between Instructor-Groups

$$= \frac{(4606)^2}{72} + \frac{(2516)^2}{38} + \frac{(2104)^2}{32} + \frac{(2263)^2}{36} - \frac{(1628)^2}{204}$$

$= 363.0$

Sum of squares between classes (10)

$$= \frac{2331^2}{36} + \frac{2275^2}{36} + \frac{1232^2}{19} + \frac{1284^2}{19} + \frac{1034^2}{16} + \frac{1070^2}{16}$$

$$+ \frac{1151^2}{18} + \frac{1112^2}{18} + \frac{800^2}{13} + \frac{828^2}{13} - \frac{13117^2}{204}$$

= 591.4

Interaction (methods x Groups)

= 591.4 - 3.0 - 363.0

= 225.4

(B). The second major step in the calculation consisted in repeating the above procedure in respect of the final scores.

Sum of squares between Methods

$$= \frac{1389^2}{102} + \frac{1249^2}{102} - \frac{2638^2}{204}$$

= 96.0

Sum of squares between Instructor-Groups

$$= \frac{988^2}{72} + \frac{518^2}{38} + \frac{352^2}{32} + \frac{431^2}{36} + \frac{349^2}{26} - \frac{2638^2}{204}$$

= 222.2

Sum of squares between Classes (10)

$$= \frac{530^2}{36} + \frac{458^2}{36} + \frac{257^2}{19} + \frac{261^2}{19} + \frac{186^2}{16} + \frac{166^2}{16} + \frac{238^2}{18} + \frac{193^2}{18} + \frac{178^2}{13} + \frac{171^2}{13}$$

$$- \frac{2638^2}{204}$$

= 365.5

Sum of Squares for Interaction (Methods x Instructors)

$= 365.5 - 222.2 - 96.0 = 47.3$

(C) The third major step in the calculation involved finding
(i) the Sum of Products for Methods
(ii) the Sum of Products for Instructor-Groups
(iii) the Sum of Products for Classes
The Sum of Products for the Interaction was determined by subtraction.

Sum of Products for Methods

$$= \frac{6548 \times 1389}{102} + \frac{6569 \times 1249}{102} - \frac{13117 \times 2638}{204}$$

$= - 15.5$

Sum of Products for Instructor-Groups

$$= \frac{4606 \times 988}{72} + \frac{2516 \times 518}{38} + \frac{2104 \times 352}{32} + \frac{2263 \times 431}{36}$$

$$+ \frac{1628 \times 349}{26} - \frac{13117 \times 2638}{204}$$

$= - 7.5$

Sum of products for Classes

$$= \frac{2331 \times 530}{36} + \frac{2275 \times 458}{36} + \frac{1232 \times 257}{19} + \frac{1284 \times 261}{19}$$

$$+ \frac{1034 \times 186}{16} + \frac{1070 \times 166}{16} + \frac{1151 \times 238}{18} + \frac{1112 \times 193}{18}$$

$$+ \frac{800 \times 178}{13} + \frac{828 \times 171}{13} - \frac{13117 \times 2638}{204}$$

$= - 38.8$

Sum of Products for Interaction (Methods x Instructors)

= - 38.8 - (- 15.5 - 7.5)

= - 15.8

Summary of Results obtained above :-

	x^2	xy	y^2
Methods	3.0	- 15.5	96.0
Methods x Instructors	225.4	- 15.8	47.3
Methods plus Methods x Instructors	228.4	- 31.3	143.3

(D) The fourth step in the calculation was to determine
(i) The Adjusted Sum of Squares for Interaction (Methods x instructors)
(ii) the Adjusted Sum of Squares for Methods plus Interaction, using the regression of the final upon the initial scores.
By subtraction the Adjusted Sum of Squares for Methods was computed.

Adjusted Sum of Squares for Interaction (Methods x Instructors)

$$= 47.3 - \frac{(-15.8)^2}{225.4} = 46.2$$

Adjusted Sum of Squares for Methods plus Interaction

$$= 143.3 - \frac{(-31.3)^2}{228.4} = 139.0$$

Adjusted Sum of Squares for Methods

139.0 - 46.2 = 92.8

(E) In the last stage of the calculation the hypothesis that both methods-groups were part of the same pupil population was investigated by using the 'F Test' to compare the variance for Methods with the variance for Interaction.

Degrees of freedom for Methods = 2 - 1 = 1

$$\text{Variance for Adjusted Methods} = \frac{92.8}{1} = 92.8$$

Degrees of freedom for Interaction (Methods x Instructors)
(2 - 1)(5 - 1) = 4

Degrees of freedom for Adjusted Sum of Squares for Interaction

4 - 1 = 3

$$\text{Variance of Adjusted Interaction} = \frac{46.2}{3} = 15.4$$

Test of difference between Methods

$$F = \frac{92.8}{15.4} = 6.03$$

Reference to 'F Tables' indicates (d.f. 1 and 3) that for significance at 5% level a value of at least 10.13 should be expected and for significance at 1% level a value of 34.12 or greater would be required.
Consequently the F value obtained in this experiment is not sufficiently large to justify the acceptance of any difference between the two methods of treatment investigated.

APPENDIX L.

Comparison between Original and Re-Test Scores.

Test No.	1.		2.		3.	
Application.	1st	2nd	1st	2nd	1st	2nd
	10	17	10	19	11	17
	12	15	13	20	14	20
	11	18	8	15	7	15
	10	19	8	15	9	18
	9	20	9	17	10	20
	12	20	14	20	11	20
	12	20	7	14	10	15
	10	15	7	16	9	19
	8	17	6	14	8	13
	10	18	6	18	12	20
	9	15	8	15	7	15
	7	13	4	10	5	17
	11	20	6	15	7	14
	14	20	15	20	14	20
	10	17	7	17	8	14
	11	20	11	15	8	16
Totals	166	284	139	260	150	273
Means	10.38	17.75	8.69	16.25	9.38	17.06