The teaching of electronics in schools and further education: a case study in curriculum change.

Hunter, Donald William

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THE TEACHING OF ELECTRONICS IN SCHOOLS AND FURTHER EDUCATION: A CASE STUDY IN CURRICULUM CHANGE

DONALD WILLIAM HUNTER B.Sc., Grad. F.R. Inst

This case study describes the development of Electronics within the curriculum in line with how both (Reid and Walker 1975, Case Studies in Curriculum Change) and (Goodson 1983, School Subjects and Curriculum Change) discussed changes in terms of theories of curriculum change.

Alternative definitions of the term innovation are reviewed and for the purpose of this study a definition is adopted which includes syllabus change and major changes of scale and strategy. The study gives an outline of the major theories of innovation and implementation strategy. Features of centralisation and rationalisation are described insofar as these features led to current educational initiatives.

An account is given of how Electronics developed as a topic within 'A' level Physics, a subject within B.E.T.E.C. (previously O.N.C./T.E.C.) and as a separate G.C.E. subject. Data on examination entries in G.C.E. and C.S.E. Electronics are presented. These data are related to the size of L.E.A.s, the type of centre, and also to explore the viability of G.C.E./G.C.S.E. provision in Electronics.

Initiatives such as M.E.P., T.V.E.I., C.P.V.E., S.S.C.R. are described as they are expected to have a significant impact on the growth of Electronics. The position of Electronics within the curriculum and its educational value are discussed. Comment is made on the Systems and Components approaches to Electronics and on the importance of project work. Teacher difficulties with project work are noted and suggestions are made on the use and range of equipment available so that a suitable teaching style may be developed.

THE TEACHING OF ELECTRONICS IN SCHOOLS AND FURTHER EDUCATION: A CASE STUDY IN CURRICULUM CHANGE

BY

DONALD WILLIAM HUNTER

submitted for M.A.(Ed) Degree

at

UNIVERSITY OF DURHAM

SCHOOL OF EDUCATION

1985

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SECTION 3. INTRODUCTION AND ACKNOWLEDGEMENTS

This case study describes the development of Electronics as a subject within the curriculum relating this development to the theory of innovation, implementation strategy and rationalisation of educational provision. This interpretation is in line with both (Reid and Walker 1975), and (Goodson 1983) and the manner in which they discussed changes in terms of theories of curriculum change.

The study reflects my own views formed on the basis of my experience as a lecturer in Physics and Electronics. During the last eighteen year, I have taught Electronics to several different courses vis: O.N.C., T.E.C., G.C.E. 'O', 'A', and Endorsement. In this time, I have been involved with O.N.C., T.E.C. Mode 3 type assessment, and as an Assistant Examiner A.E.B. 'A' level Electronics Systems and Project Moderator A.E.B. 'O' level Electronics.

Throughout the study the term Electronics is used to embrace transistors, I.C.'s, microprocessors etc., rather than the term Microelectronics as the latter term is too frequently immediately equated with Computing, programming and key-board skills. The abbreviations commonly used and given in the study are summarised in the Appendix.

Within the scope of the case study, there was insufficient space to consider computer assisted learning, simulation of processes, C.D.T. etc., and it is recognised that features such as growth in C.D.T. and Computer Science may be significant in terms of the statistics developed.

As the study was restricted to the regions covered by the Microelectronics Education Programme (M.E.P.) the statistics omit Scotland, the Channel Isles, and Overseas Centres. Also Independant Schools were omitted from the data when L.E.A.'s were compared as the activities of such schools is not affected by L.E.A. policy. It is expected that there will be some minor errors as some data may refer to provisional entrants rather than to actual entrants. Where the number of entrants for each centre was not specified an average figure was assumed; insofar as the Boards concerned involved small number of candidates usually within a limited geographical area the effect of averaging is considered insignificant on the final graphs.

ACKNOWLEDGEMENTS

I wish to acknowledge the assistance given by the many Examination Boards who kindly provided the data collated in the Appendix, especially the University of London Schools Examination Council and the Associated Examining Board for the access provided to data. In this context the conclusions drawn from the use of the data, also the ideas and opinions expressed are those of the writer and not the Examination Boards.

Thanks are also due to the Audit Bureau of Circulation limited by Guarantee for the circulation figures which they kindly provided, the conclusions drawn from the use of the data are those of the writer.

I would like to express my thanks to many people who discussed with me their experiences and opinions of Electronics within the curriculum, provided literature etc. Although it may be invidious to name only a few, special thanks are due to:

Mr. A. Ashman for his advice on the style and scope of the case study.

Mr. G.W. Pilliner, and Mr. R.J. Hughes for their many comments.

Mr. J. Mee for allowing me access to data which he had collected.

The library staff at both the School of Education, and Monkwearmouth C.F.E. who assisted me in obtaining journals, texts etc.

Ann Smith who typed the thesis; my sister June Gustard who corrected the proofs; and to my wife, Marjorie, for her patience while I filled the house with paper.

SECTION 4: INNOVATION

Several alternative definitions of the term 'innovation' which are relevant to the scope of this thesis are considered. The emerging themes of innovation from the 1930s are then described leading to detailed accounts of the themes which were given about 1970 by Rogers and Shoesmith, Havelock, Schon and House. The themes are followed by a consideration of some of the many factors which influence the attitudes of Local Government, Public, Teachers etc. to innovation. The Section conludes with a review of the various implementation strategies described in the literature to take account of the various attitudes so that an innovation may be successfully achieved.

"The price of the employment of models is eternal vigilance"
R. B. Braithwaite, p93, Scientific Explaining (Cambridge University Press 1953)

4.1 INNOVATION Alternative Definitions

4.1.1 Literature reviews such as those of (Dalin 1973) and Nicholls 1983, 33-41) showed that in defining the term 'innovation' there were conflicting views involving concepts of scale and control.(Miles 1964, 14) limited the scope for the purpose of his book: "it would seem helpful to consider innovation as being willed and planned for rather than occurring haphazardly"; (Rudduck and Kelly 1976, 11) wrote of a "deliberate attempt to improve practise in relation to schools". By excluding haphazard changes, such as those which occur despite legislation, attention was focussed on those deliberate changes, which are conscious practices, presumably capable of control. (Nicholls 1983, 4-6) reviewed alternative definitions of the term 'innovation' and she submitted:"An innovation is an idea, object, or practise perceived as new by an individual which is intended to bring about improvement in relation to desired objectives, which is fundamental in nature, and which is planned and deliberate."

4.1.2 (House 1979,1) quoted R.G. Paulston "Innovation is viewed as relatively isolated technical or programmable alteration or low level change whereas reform involves a normative notional and broad structural change." In doing so House touched upon his earlier work: (House 1974, 57-58) and to the two types of innovation identified by Norman: the variation and the re-orientation. The variation requires no drastic shifts within the existing framework, whereas re-orientation involves "new goals, new values, new, as well as realigned, power structure, and shift in cognitive structure." The re-orientative innovations make it more necessary "to gain resources politically, support skills technically, propogate new values emotionally, and teach new cognition intellectually."

(Rich 1981, 2-39) also made a distinction in the terms innovation and reform. He distinguished between two types of reformer: programmable, involving curricula (Sic) programmes and innovation; systematic, involving authority relationships, power and resources. Rich stated a "programmatic reformer" is an innovator and much more, and described an "Innovative Establishment Educator" as someone who accepting what is best in the existing system believed "when problems arise innovations should be introduced and effectively implemented."

For the purposes of this study innovations are considered to be: New or improved practices deliberately brought about by individuals acting either in the role of teacher or of administrator. These changes include 'the variation' seen as a syllabus change and 'the re-orientation' seen as a major change of scale and strategy.

4.2 MODELS OF INNOVATION THEORY

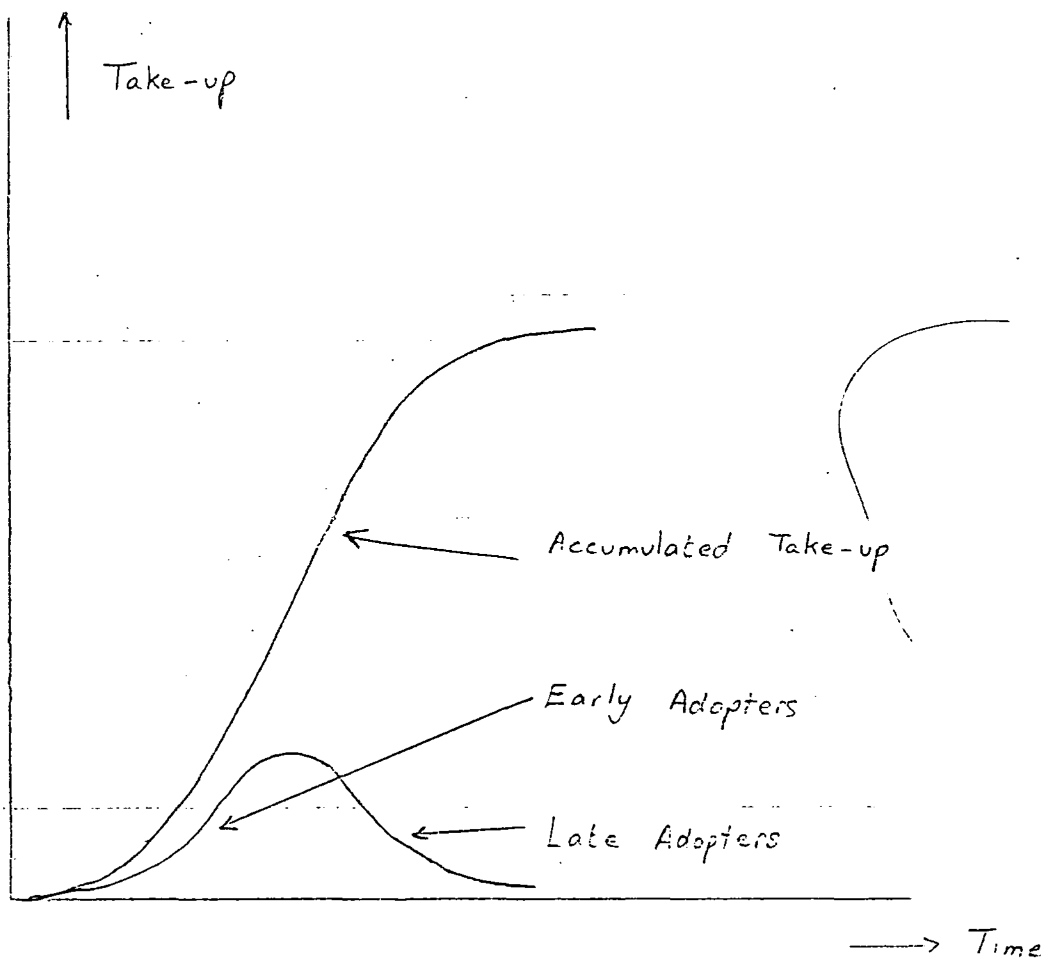
4.2.1 Early work on education innovation was carried out by Mort at Columbia University in the late 1930's. (Hoyle 1969, 383) wrote "Mort's studies were focussed on financial rather than on sociological variables." In this work Mort made a comparison with agricultural innovations and he observed a considerable time lag for the widespread adoption of new educationbal ideas. Since then the rate of educational innovations has accelerated: typically (Marsh 1964, 249) stated that the P.S.S.C. Project adoption time, 1956 - 1963, "Makes a shambles of Mort's earlier schedule of curriculum innovation"; (Rogers and Shoesmith 1971, 60) made a similar point by reference to Driver Training 1930's - 1950's, and Modern Math, 1950's - 1960's. (Mort 1964) himself had forecast that as earlier ideas were assimilated a faster rate of development would occur. His awareness of assimilation was shown when he wrote (p.324) "Not all innovations spring fully armed from the brow of some Jove. Some of them are old strands in new patterns."

4.2.2 Following the contribution of Mort several other writers made early contributions to innovation theory:

i) The 'Modern Math' was investigated by (Carlson 1965) who replaced Mort's financial approach with a sociological one. (Carlson 1965, 5) saw an innovation as having a life cycle: adoption, diffusion and unanticipated consequeneces. He suggested a step-flow mechanism with an S-curve adoption similar to that of a chain mechanism. (Diagram 4.1)

Diagram 4.1

Carlson: S-curve adoption



ii) When making his first contribution (Rogers 1962) proposed stages of awareness, interest, evaluation, trial and adoption in the process of innovation; at this time he omitted "design". Rogers later made further contributions (4.2.7).

iii) (Clark and Guba 1965) extended an original conception by Clark analysed four aspects of educational change: research, development, diffusion, and adoption. This basic Research, Development and Diffusion (R D and D) model was referred to by (House 1973, 3) who admitted that decentralisation, as well as social and political forces may not have been given the attention Clark and Guba required. (House 1974, 217) commented on the evaluation study of (House, Kerins and Steele 1972) which indicated that the "follow up" stage is highly significant compared to the "demonstration", he described the conflict with the views of Clark, and Guba and "contended that Clark, and Guba had already changed their own conception of their Schema on the basis of later experience ....", (p. 220). (House 1979, 2) credited Clark and Guba with the "finest conceptualisation ....." of the R D and D model.

4.2.3 Whereas Mort, Carlson, Rogers, Clark and Guba wrote on the basis of their experience in U.S.A. (Williams 1966) of the N.F.E.R. gave a general strategy affecting educational change: preparatory, select pilot school, sustain new approach, teacher-training and evaluation. He foresaw problems of staff turnover when suggesting staff duplication in pilot schools; other features suggested were that the pilot school should be located near to an advisory centre and other pilot schools, and that the larger schools could most probably provide resources in the form of apparatus, accomodation, time table capacity etc. This strategy remains relevant as do the requirements he gave to sustain a new approach: in-service training to instill the philosophy, providing a group identity through social support and stimulus, getting teachers involved, allowing teachers a freedom of approach such as choice and development of topics within the preferences and strengths of individual teachers, continuing the free time required to set up the course, and providing relevant evaluation. Williams foresaw, the later problems of the evaluator of the innovation when he wrote "Too often reform movements pay more regard to fashion than fact"; a comment similar to that of (Kerr 1964, 24) "It is easier to form opinions than to make judgements."

4.2.4 (Nicholls 1983, 36-37) reviewed attempts by (Trump 1967), (Watson 1967) and (Rubin 1968) to identify the stages in innovation. (Trump 1967) described procedures for initiating innovation:

i) Analayse co-operatively reasons for present practices;

ii) Discover what people want that is different from what they are doing;

iii) Make tentative decisions about the priority of proposed changes;

iv) Plan the innovation carefully in terms of teacher preparation, student preparation, procedures to be followed and the anticipated effects of the innovation;

v) Determine the times and technqiues for evaluation.

4.2.5 (Watson 1967, 110) after an analysis proposed a model with ten stages: sensing. screening, diagnosing, inventing, weighing, deciding, introducing, operating, evaluating and revising. Some of these features resembled those given by (Rubin 1968, 159-162) who subdivided three sequential operations as follows:

4.2.5.1 Preliminary analysis

i) Diagnosis of a weakness
ii) Analysis of the responsible factors
iii) Comparison of alternative correctives
iv) Selection of the best corrective

4.2.5.2 Strategy Selection

i) What kind of innovation was to be installed?
ii) Who will engineer the installation?

iii) What conditions characterised the target environment?

4.2.5.3 Action

i) Analysis of the innovation's requirements in training, material, and linkage to existing systems.

ii) Initiation of motivating pressures through inducing dissatisfaction and illuminating the reward.

iii) Initiation of the influencing strategy.

iv) Initiation of the preparatory activities.

v) Installing the innovation.

vi) Supporting the transition from old to new.

vii) Linking the innovation to the permanant system.

4.2.6 The suggestions given by Williams, Trump, Watson and Rubin etc. may have features in common and in total they embrace much of the subsequent work. However, any single approach is rather crude and simplistic, not individually capable of preventing what (Hoyle 1969, 16) referred to as the "unplanned drift" of curriculum.

(Kerr 1968, 15) commented about the absence of a coherent theoretical framework and the need for more theory, research and evaluation. Similarly (House 1974, 228) wrote "Rivlin labels the strategy of the 1960's 'random innovation'."

Almost simultaneously as if to answer this criticism theoretical contributions were made in the form of three studies of models.

4.2.7 (Rogers and Shoesmith, 1971) writing (on the basis of limited empirical studies to an academic audience) recognised that any model would be limited by a deficient research tradition. They identified three major division, (p. 103): Antecedents, Process, and Consequences; and they gave the stages in the process of Adoption: Knowledge, Persuasion, Decision, and Confirmation. (Nicholls 1983, 34) suggested that this analysis of adoption had much in common with the 'life-cycle' proposed by Carlson (4.2.2).

(House 1979, 2) described Rogers as "The master sythesizer of cross disciplinary research on innovation", and he made reference to a lecture given in 1975 by Rogers, in which Rogers criticised his own earlier work in three points:

i) it was process orientated with a consequent lack of identity to events;

ii) it was biased towards the view that innovation implies good;

iii) the unit of analysis was not necessarily the individual.

It was criticism of this nature which led writers such as Clark and Guba to change their conception, (4.2.2 (iii) and 7.1.1).

4.2.8 (Havelock 1969, 1971) reviewed 4,000 studies in many fields including education and suggested three models.

4.2.8.1 Research, Development and Diffusion Model (R D and D). This is innovator determined, who prescribes to a presumed need of a receiver (target) group. This initiative is with the Researchers, Developers Disseminators and the receiver is passive.

(Havelock 1971) identified the major characteristic as:

i) It assumes a rational sequence of activities from research to development to dissemination.

ii) It implies that planning on a large scale has taken place.

iii) It involves a division of labour with a clear separation of roles and functions.

iv) It assumes a passive consumer who is willing to accept the innovation.

v) It involves a high level of initial development costs before dissemination takes place.

This model was criticised by (House 1974) for not taking into account social effects.

(MacDonald and Walker 1976, 38) referred to the change agent, central innovator agency, preparing and disseminating a packaged solution, however, (Nicholl 1983, 15) suggested that given, what is often a radical approach, teachers will not remain passive, but will impose their own opinions. Indeed this occured to such an extent that (MacDonald and Walker 1976, 26) cited the case where to retain control in U.S.A. the centre mounted an attack on the periphery.

4.2.8.2 Social Interaction Model (S.I)

This is sender determined, receiver reaction being assumed. The sender assesses the reaction of the receiver and the sender determines subsequent changes. Diffusion is through a process of social interaction. The model emphaises the need for linkage mechanisms, Becher's change agents who are able to identify and strengthen the diffusion network and exchange.

Havelock 1971, 85-86) gave the characteristics of the model as:

i) The individual user or adopter belongs to a network of social relations which largely influences his adopter behaviour.

ii) His place in the network (centrality, peripherality, isolation) is a good predictor of his rate of acceptance of new ideas.

iii) Informal personal contact is a vital part of the influence and adoption process.

iv) Group membership and reference group identifications are major predictors of individual adoption.

v) The rate of diffusion through a social system follows a predicatable S-curve pattern (very slow rate at the beginning, followed by a long late-adopter or 'laggard' period). (4.2.2).

4.2.8.3 Problem-Solving Model (P.S.)

In this model the receiver perceives a problem and seeks a solution wherever available from the sender (change agent). The change agent functions as a resource consultant in collaboration with the receiver.

According to (Nicholl 1983, 17) the advocates of this model usually emphasised five points:

i) User need is the paramount consideration, this being the only acceptable value-stance for the change-agent; what the user needs and what the user thinks he needs are the primary concern of any would-be helper.

ii) Diagnosis of need always has to be an integral part of the total process.

iii) The outside change agent should be non-directive, rarely if ever, violating the integrity of the user by setting himself up as the 'expert'.

iv) Internal resources, that is, those resources already existing and easily accessible within the client system itself, should always be fully utilised.

v) Self-initiated and self-applied innovation will have the strongest user commitment, and the best chances for long term survival.

Many of the professional and social factors discussed later are relevant to this model.

In his publication (Havelock 1971) interacted these three models to formulate a link model. (House 1979, 3) later stated that "in practise the R D and D model has not worked very well" yet it "still dominates much government thinking". This comment applied not only in U.S.A. but also to many U.K. programmes such as those of Nuffield and the Schools Council.

4.2.9 (Schon 1971) foresaw a phase of rapid, uncontrollable unpredictable changes in which outward spread was a key idea and speed of response was important.

4.2.9.1 The basic model is Centre-Periphery and involves three assumptions:

i) The innovation to be diffused exists, fully realised, in its essentials, prior to its diffusion.

ii) Diffusion is the movement of an innovation from a centre out to its eventual users.

iii) Directed diffusion is a centrally managed process of dissemination, training, and provision of resources and inventions.

4.2.9.2 Schon argued that the effectiveness of this model depended on four features:

i) The level of resources at the centre.

ii) The number of points on the periphery.

iii) The length of the radii, or spokes, through which diffusion takes place.

iv) The energy needed to gain a new adoption.

(Whitehead 1980, 3) argued that these features were irrelevant in schools as the L.E.A. was the centre; (MacDonald and Walker 1976, 48) observed that "The developers command no-one and can afford to offend very few." This model was a linear model which Schon identified with Rogers within this framework he dismissed as simple minded Rogers equation of diffusion with communication: (MacDonald and Walker 1976, 14). Schon himself modified his presentation of the centre-periphery mode by substituting 'infrastructure technology' for 'spoke length'.

4.2.9.3 Schon proposed two variants of this model:

i) Johnny Appleseed in which a dreamer (bard) roams his area spreading a message; this variant has overtones Social-Interaction and the bard is close to being an innovator-entrepreneur hybrid.

This model allows adoption to special conditions but not to the development of a centre.

ii) A 'Magnet' at the centre attracts agents of diffusion. Schon saw this as the more attractive variant as it had the advantages of tighter control of teaching and greater efficiency in the use of teachers; it's disadvantages were that it had less control over what happened afterwards, and less variation in adaption to the particular needs of the outposts.

4.2.9.4 Proliferation-of-Centres Model

Schon extended his first model to overcome inherent sources of failure by clearly distinguishing primary and secondary centres. The primary centre supports and manages the secondary centre; the secondary centre represents the scope of the whole system in the earlier model. It is in the secondary centre that diffusion occurs. Each new secondary centre provides an exponential increase of the primary. This remains a linear model. Schon predicted failure due to resource limitation and conflict between the central and regional philosophies. Although this model was attributed to various schools council projects, (Whitehead 1980, 3) commented that the centre comprised the innovator and management team usually appointed for four years whereas appointments at the teacher centres within the secondary stages are usually permanent so that the model could not be applied to Great Britain.

Whitehead (p.4) further commented on another Schon variant-the Periphery Centre Model. This model required two way communication to improve ideas/matrials. Failure was predicted here as teachers/parents reject innovation. In this model cyclical elements were being recognised.

4.2.9.5 Shifting centres model

Schon proposed a model in which there was no clearly established centre and which involved a changing message. Although this differs from the centre periphery model diffusion still occurred. (Whitehead 1980, 5) referring to (Shipman 1974, 122) likened the support from a centre to the aid given to less developed countries, could the support lead to accumulated resources so that the secondary centres become self-sustaining engendering their own momentum. (Nicholls 1983, 21) commented "It is clear that there are certain similarities between Schon's centre-periphery model and Havelock's R D and D model and so some of the strengths and weaknesses already mentioned in connection with educational innovations developed in the latter would also apply to those developed in the former." The present economics of the less developed countries puts Whiteheads optimism into a stark perspective.

4.2.10 (House 1974) made a contribution which was discussed in (MacDonald and Walker 1976) also (Kelly 1982). (MacDonald and Walker 1976, 18) wrote of House "His focus is firmly on educational innovation, and to a large extent arises out of personal experience of the curriculum reform movement. He is able to take into account nearly a decade of attempts to implement one major variant of the centre-periphery model, the R D and D paradigm first identified by Havelock." Schon had already indicated the significance of socio-economic factors.

(House 1974, Chap.2) extended some earlier work, reviewed by (MacDonald and Walker 1976, 19) to form a social model composing two kinds of social groups.

4.2.10.1 Rural, a homogenous society. Ideas are communicated by personal contact between individuals of comparable social status and the spread of ideas is affected by distance. Within this society innovations are accepted by individuals being referred to as 'household' innovations and spread as waves. (p.16): "Each new adoption increases the speed of diffusion .... The snowball effect is powerful."

4.2.10.2 Urban, a heterogenous society. Distance is now less significant as barriers of social status are the most significant. House proposes that within this society innovations leap from one urban complex to the next largest in size, independant of distance. Such innovations are referred to as 'entrepreneurial' innovation (p.16): "Entrepreneurial risk often involves a higher social, economic, or political risk." Within education the spread of P.S.S.C. materials had already been noted by (Marsh 1964, 263), he observed that the spread was in the form of clusters, independent of authority boundaries reflecting professional contacts. It was also noted that staff who change employment either stop the use of the innovative practise or start a new cluster. However, (Peterson and Emrich 1983, 232) wrote of a 1974 T.A.G. project in U.S.A. which reported few "ripple" effects were evident.

4.3 INDIVIDUAL PARTICIPANTS WITHIN THE EDUCATIONAL MODEL

(Bolam et al 1978, 222) describing the changing eductional climate in the 1970's wrote "First successive cutbacks in public expenditure following the 1973 oil and economic crisis have led to strong lay and political demands for cost-effectiveness and accountability: dirigism is now in the air. Second, there is now much greater public scepticism and debate about what are unusually termed modern methods...." (Kelly 1982, 21) wrote "economic recession has resulted in serious reductions in the amounts of public money available for education" and gives this as a factor of increasing significance in education.

(Nicholls 1983, 9) referred to Coombs who suggested that if a steady flow of clients was assured within schools then interest in innovation was reduced, there was no equating of funds to performance.

The climate of falling roles, economic recession and a changing social attitude increasingly impinged on education and were features affecting innovation from the later 1960's. Such features can obviously lead to conflict over the direction and nature of educational change.

4.3.1. THE LOCAL GOVERNMENT

4.3.1.1 L.E.A.s may be subject to the whims and vagaries of elections, consequently long term funding cannot be assured (Saran 1979, 39) attempts to fund major capital projects over a short term may not be feasible. So although the administration "has the authority to precipitate a decision": (Brickell 1964, 503), it may not have the will. (MacDonald and Walker 1976, 44) referring to curriculum development work wrote "The rhetoric is premised on an unexamined assumption: that all of us concerned with the education of pupils - teachers, administrators, advisers, researchers, theorists - basically share the same educational values and have overlapping visions of excellence." Perhaps local councillors have other values and priorities! Other than capital expenditure on buildings and the support required for the provision of staff, capital equipment and consumables there can be further hidden costings. (Nicholss 1983, 5) commented on the costs incurred as staff are released for initial and on-going planning, the scale of such costs not always being apparent as "they tend to underestimate the time needed" (they = teachers). (House 1974, 19) wrote "For many innovations there will be a threshold unit below which an innovation cannot be adopted or sustained" there is an "economic and technical feasibility of an innovation for a given town." Albeit the financial structure in the U.K. differs from the U.S.A. but the comments of House still apply: a local authority cannot gain limitless funding from central government, it must determine it's priorities. If an innovation is to succeed an L.E.A. can make a major contribution by allocation of resources, selection of staff, and guidance given: (Peterson and Emrick 1983, 223 and 228). (Hoyle 1974) stated "More broadly the local Authority can make a significant contribution in the provision of social and community facilities such as libraries." (Eggleston 1977, 47) similarly noted the crucial role of publishers. (House 1974, 45) indicated how authorities controlled one resource, that of staff appointments by "stacking the deck" and "lining up the ducks."

4.3.1.2 (Schmuck 1974) recognised that on the part of the L.E.A. changes will be required in the status groupings and communication networks as there is incompatibility of organisational arrangements with innovations. (MacDonald and Walker 1976, 122) wrote "curriculum projects usually nurse ideologies of reform in the organisation of the school and the nature of education itself." Such a view was expressed by Coombs and given in (Nicholls 1983, 8): "widespread transformation of attitude towards change in education." If an innovation is to gain support from the administration then the changes required must not threaten the power wielders especially the "informal elite" and their control: (House 1974, 47). (Gross et al 1971, 200) related failure of innovations in many cases to poor administration, they refer to weaknesses in role identity, lack of resources, and poor appreciation of the skills and knowledge of teaching staff. The work of (Dickinson 1975) suggested that innovations may be opportunist and often related to re-organisations involving pupil intake.

4.3.1.3 (Bolam et al 1978, 228) in a survey carried out in 1973-75 for the DES, made several criticisms of L.E.A. advisers with respect to monitoring procedures, analysis of benefits, application of management theory, and consultancy role. A survey (p.178), revealed the level of advisery follow up to be poor; and (p.180), dependent on the experience and background of the adviser. (Bolam et al 1978, 163) "showed that half of the innovations, with which the advisers were associated, derived from policy changes at a higher level." In conclusion training and an advisery role were recommended for L.E.A. advisers.

4.3.1.4 The importance of the Chief Administrator was reflected by Proposition 5 of (Griffiths 1964, 434) "The number of innovations is inversely proportional to the tenure of the chief administrator" also Proposition 6 "The more hierarchial the structure of an organisation the less the possibility of change." (Carlson 1965, 10) in a study of School Superintendants noted their influence as a source of ideas from outside; the role of School Superintendant in U.S.A. is equivalent to that of Chief Administrative Officer in the U.K., and Carlson's comment was incompatible with that of (Bolam et al 1978, 163). Charts in Bolam et al do not support the concept of the administrator promoting an idea! In U.S.A. Carlson was able to relate the rate of innovation adoption to the social status of the superintendant and stated (p.330) the "School superintendant is neither a helpless victim of his local budget, nor a powerless officer holder dominated by a superordinate school board." When (Griffiths 1964, 435) gave Proposition 7: "when change in an organisation does not occur it will tend to occur from the top down not the bottom up" may not this suggest tacit approval and formal provision of resources being given to what is already 'routine'? (Peterson and Emrich 1983, 247) accepted this point but continued to stress the importance of Adminstrators in establishing suitable conditions.

4.3.1.5 (Hooper 1969, 420) on the topic of funding wrote "It had led to innovations being pushed to the outside of an educational institution: when the grant money runs out, the innovation is carefully peeled off without damaging the structure, and thrown away."

The significance of innovation to higher management was indicated when (House 1974, 256) asking "why innovate?" referred to (Travers 1973) ".... to make education more efficient and more productive so that it will cost less", also the materials and equipment of such a technology can carry conservative political messages, either explicitly or implicitally, that favour those in power." House added "If the school becomes receptive to a constant stream of innovations, each replacing the last, and each an 'improvement' one has created an eternal market for innovation products." Such a step is seen as an important attitude in industry, commerce, and re-training. The process of innovation within education was seen as having far ranging implications involving features outside of education; House continued "Education thus becomes more dependent on external controls - on those who control the flow of innovations."

4.3.2. THE PUBLIC

Parental influence other than via elections is increasing. In general (Brickell 1964, 502) thought a "climate of interest" can be created. (Brickell 1971, 404) considered that although public neutrality was harmless "The public must be informed about a change so that it will not come as a surprise and arouse opposition for that reason alone." (Kelly 1982, 190) touched on parental influence when he suggested that many projects have been aimed at pupils of "average ability" to avoid conflict over the nature of associated exams. Other evidence of increasing parental participation was shown by their involvement as school governors towards the end of the time period involved. (Becher et al 1981, 4-6) and (Taylor Report 1977) gave details of interested groups. (See 5.1.5)

4.3.3 THE INNOVATORS, CHANGE-AGENTS

4.3.3.1 The innovator, change-agent, and opinion leaders have many of the motivations of teachers; they are often themselves teachers on secondment. In general innovators etc. have leadership qualities, areas of special knowledge and the ensuing professional aspirations. The importance of field agents as a link was stressed several times by (Paisley and Butler 1983, 221-229 and 75-78).

Within the central team there may be role definition, (Nicholls 1983, 39), (Rogers 1962) indicated that the innovator was not always the most respected member of his social system. Indeed, (Miles 1964, 642) referred to the "less heroic characteristics" of the innovator and suggested that one characteristic was the inability to cope with the problem of survival of the innovating team. A project leader was seen as being charismatic, pragmatic, and able to function within the various constraints, even to the acceptance of scaling down innovation to hold it within a budget. Also the project leader was seen as an entrepreneur who pragmatically trades off. (House 1974, 71) wrote "The entrepreneurial group can bargain for increased formal rewards, thus shifting the reward structure within the organisation." (MacDonald and Walker, 59-74) considered that trade offs may lead to a two images concept giving a detailed example from the Geography for the Young School Leaver project; elsewhere it was suggsted that concept adulteration couple with institutional conservatism also helped to promote two images. (House 1974, 56) noted the administrative entrepreneur "can operate best when there is a fragmented or loose bureaucratic structure" this is in accordance with (Griffiths 1964) Proposition 6 and was suggestive of the need to trade-off. More alarmingly it was suggested that trade-offs may extend to evaluation.

4.3.3.2 Innovations were described as affording career opportunity, although (MacDonald and Walker 1976, 39 and 47) doubted the reality of the concept of career optimists joining a 'band-wagon'. Instead (MacDonald and Walker 1976, 46) noted that in seeking some self-improvement it was possible to become "unwittingly the spearhead of an institutional confrontation." Staff seeking for career advancement were unlikely to engage in conflict with the system so diluting feedback, indeed there was a greater danger that they formed an inward looking elitist group further inhibiting communication. (Whitehead 1980, 21) doubted that promotion prospects would be enhanced by association with recent developments and wrote "Another consideration which is undoubtedly avoided in the United Kingdom literature, is that of financial incentive." (House 1974, 73) mentioned "the flatness of the reward structure", "more material extrinsic rewards are scarce", and gave student enthusiasm as an acceptable reward.

4.3.4 THE HEAD TEACHER

4.3.4.1 The Head Teacher can help to assist innovations but perhaps not as far as some would expect; (House 1974, 53) suggested a conservatism within the school when he wrote "Any innovation has meaning only within a particular social structure and the social structure of schools is such that an innovation pandemic is unlikely." The structure, climate, and organisational health of a school was consequent upon the L.E.A. appointment of a Head Teacher even though as (Nicholls 1983, 70) observed there may be doubt as to how to create a suitable climate. (House 1974, 40) generally saw educational management as having a conservative attitude there being two types of appointment: career-bound and place-bound. The career-bound appointment was more likely to accept an innovation 'band-wagon' as this afforded an opportunity for attention seeking. An appointment from outside an authority was free of the social restraints identified by (Carlson 1965, Chap.2) and could be considered to have a mandate for change. (House 1974, 44) did not develop this aspect of a career-bound man unfreezing a social structure other than reference to a health programme, (p.43). He observed that the career-bound, more mobile, of the officers supported easy to adopt innovations and were orientated towards their professional group; those innovations which were difficult to adopt were supported by place-bound locally orientated officers.

4.3.4.2 (Nicholls 1983) devoted a chapter to the function of the Head Teacher in innovation and she wrote (p.12) "Two research studies suggest that while the Head Teacher is frequently the initiator of innovation in his own school, it is doubtful if he is the source of innovative ideas." She referred to (Brown 1971) who in a study of innovations in primary schools observed that the Headmaster was greatly influenced by H.M.I.s, the mass media and official publications. (Carlson 1965, 10) saw the Superintendent as a source of ideas from outside which he needed to actively promote. Earlier reference to (Bolam et al 1978) indicated that a range of links must be operative. An H.M.I. study 'Ten Good Schools', 1977, identified the most important single factor in good practice as the leadership of the Head Teacher; however, good practice and innovativeness need not be synonimous. Indeed (Dickenson 1975) reported that innovations were often introduced to solve the Head Teachers immediate problems.

4.3.4.3 (Hoyles 1968) saw the Head Teacher as having the necessary freedom but accepted that he was limited by the quality and stability of his staff. The autonomy of the teacher within the classroom according to Hoyles, presented the Head Teacher with a complex and difficult task to affect organisational changes to accommodate innovators.

4.3.4.4 (Nevermann 1974) identified four types of school structure:

i) The authoritarian-bureaucratic type in which the principal takes decisions autocratically in a hierarchial structure.

ii) The consultative type in which the principal retains final authority though he delegates more and uses consultative procedures.

iii) The collegiate type in which authority rests with the professional staff, and the principal acting as an executive, and on which pupils and parents may be consulted.

iv) The full participatory type in which authority rests with professional staff, students, and perhaps parents and non-professional staff.

(Taylor 1968, 89) referred to somewhat similar work by Lippit and White in their investigation of leadership roles and social climates in Youth Clubs.

4.3.4.5 Obviously the character of the Head Teacher may determine which structure was closest to that of the school. (Hoyle 1969), (Nicholls 1983), and (Kelly 1982) referred to Halpin who investigated organisational climates identifying six climates, of these the open climate was described as: "There is a high level of morale and teachers will work together. These tasks are facilitated by the Principal's policies. Group members enjoy friendly relations but do not feel the need for a high degree of intimacy. The Principal sets a good example by working hard and he either criticizes or helps teachers according to the circumstances. He provides subtle direction and control but does not monitor the work of his staff too closely. He is in full control and provides leadership for his staff": (Hoyle 1971, 387).

4.3.4.6 (Kelly 1982, 138) wrote "The more open a school is the more likely it is to absorb innovations"; (Nicholls 1983, 67) added a less positive note quoting Hughes, "only certain aspects of organisational climate may be related to innovativeness." (Nicholls 1983, 67) wrote "Using a different measure of organisational climate, another study (Hilfiker 19709) also found a relationship between innovativeness and openness (characterised by ready accessibility, co-operative attitudes, tolerance of internal change and permissiveness of diversity in social situations) and trust (the degree to which an individual perceives interpersonal relationships as characterised by an assured reliance or confident dependance on the character, ability, or truthfulness of others)."

The necessary climate and organisational health is complex. (Bullock 1980, 23) stated "any activity within an institution can mean different things to different people, depending on their expectation of the activity, their pre-conceived ideas and assumptions about the system and their expectation of the personnel in it."

4.3.4.7 Should a school be successful in establishing an innovation then as some staff are career orientated they will take advantage of the success and move to more senior appointments. (MacDonald and Walker 1976, 39) indicated that Shipman suggested staff changes made the Social Interaction mechanism "very vunerable", whereas (Whitehead 1980, 20) considered that this problem of atrophy was "rarely mentioned." Even more in contrast is the view of (MacDonald and Walker 1976, 114) who implicitly doubted the permanance of the Social Interaction network writing "The enduring achievements of the project have been less in the generations of networks of individuals and more in the creation of organisations and institutions." Thus external contacts can be re-established and staff atrophy may not be critical but within a school staffing stability can create the necessary climate and in consensus it is better to have committed staff within the school rather than to graft on or add experience from external staff.

4.3.4.8 Teachers will expect the Head Teacher to be aware of problems and (Nicholls 1983, 52) noted that innovators, Heads of Departments, would look for prompt support. Such support would be analysed by staff, those involved with the innovation and being asked to work harder will view the Head's approach to both 'lazy' and 'weak' teachers with keen interest: (Becher et al 1981; 93). (Bernbaum 1976, 22) suggested two models of Head Teacher which may be affective "skilled and trained adminstrators capable of a kind of scientific and detailed control of decision-making processes" and "a non-directive role....cannot possibly be the essentially dominant figure of the past." (Hargreaves 1982, 255) echoed the last point by qoting Razzel's comments about the era of the autocratic Head imposing his thumb print, being almost over.

4.3.4.9 (Nicholls 1983, 87) writing of the Head Teacher stated "His position is a difficult one because he carried the ultimate legal responsibility for the curriculum. While he cannot, and some would argue should not, carry out all the tasks associated with the management of innovation, it would be reasonable for his teachers (and governors or managers) to expect him to have sufficient knowledge and expertise to undertake certain leaderships roles.", adding "The increasing number of in-service courses in educational management is a recognition of this fact."

4.3.5. THE TEACHERS

4.3.5.1 Teachers have a crucial role in educational innovation, considerable attention was given to their problems in the class-room by several writers. (Nicholls 1983, 41) wrote "an innovation frequently requires teachers to give up practises in which they feel secure and display high levels of competence and to adopt new practises in which, at least temporarily, they feel less secure and where possibly be less competent. There are expectations that teachers should be competent and some may not be willing or able to tolerate even a temporary incompetence or to tolerate feelings of insecurity." (House 1974, 73) commented "The necessity of relearning acts as a deterrent. New skills make old skills obsolete, and there comes a time when it is no longer worth the effort of learning new skills to master innovation." (Marsh 1964, 251) wrote "even innovators work within the limits of their experience." The consequent inertia of some teachers can then give rise to the administrative view expressed by (Miles 1964, 11) "that the teachers who will do this teching are an ineducatable lot of dunderheads who are the main barrier to innovation."

4.3.5.2 It is this attitude which led to the concept of the teacher as a resistor. (House 1974, 70) referred to the isolation and resistance of the teacher within the classroom and wrote (p.13) "....they adopt only bits and pieces, worrying about how even these will fit into the local setting. As always they are concerned about their social group and this has profound implication for educational change." (Miles 1964, 634) saw the professional identity of the teacher as resisting change. (Brickell 1964, 505) was less emphatic "The early questions, doubts and hesitance expressed should be distinguished from outright resistance to change." Similarly (Gross et al 1971, 196-7) questioned the concept of resistance to change and suggested that the failure and opposition lay in inadequate clarity of role, lack of skills and knowledge, lack of resources, and an inadequate school schedule: all management failures. They recommended that the teachers view of problems be accepted. The view given by (Klein 1976, 41) of resistors was in a sense questioned by (Olsen 1980, 3) who doubted the existence of resistors insofar as the teachers can work well in well functioning systems. (Holt 1981, 10) referring to teacher initiative in new, open, schools wrote of "teachers personal committments to openness and change", with administrative protection initiative functions more smoothly. (Marsh 1964, 267) on the subject of the P.S.S.C. project in U.S.A. rather than write of resistance instead wrote "Ultimately then it was the class-room physics teachers ignoring the tendency towards exclusiveness of both scientists and educators, who reconciled scientific strategy and educational practise and made the P.S.S.C. viable." (Mort 1964, 327) went so far as to suggest that when innovation was very slow it's authenticty should be questioned. (Atwood 1964, Chap.2) used anthropological interaction theory to explain why involvement-initiative causes less resistance.

4.3.5.3 The importance of early involvement was stressed by many workers: (Petersons and Emrick 1983, 228), (Rogers and Eichholtz 1964, 313) indicated the importance of predisposition which they suggested depends on social mixing, the reading of the teacher, and the resources available. Predisposition could be affected by the public climate of interest noted earlier. (Brickell 1964, 524) also suggsted that staff could be involved at all stages through professional organisation.

The need for teacher involvement was recognised by (Nicholls 1983, 74) who criticised the use of the teacher in a merely supportive role but "unable to act as a critic at the level of ideas." It was suggested that to regard the teacher as conservative and an impediment was naive, management should "devise implementation strategies for action-research to account for and circumvent this influence."

4.3.5.4 (House 1974, 254) identified that "The teacher's behaviour is learned by imitation and tradition..."; the structure of teacher selection training etc., was described as leading to a conservative attitude on innovation. (Mann 1979, 194) suggested that in the 60's and 70's teachers were relatively young, unprepared to challenge convention thus reinforcing tradition. (House 1974, 64) identified this conservative attitude as leading to a low level of entrepreneurism if not taken into account in the structure calling for "more structural flexibility, lack of specificity, and less rigorous role definition." To the latter end (Musgrove 1968) used the term role-hybrid. Such a flexible role was a major shift from that which (Brickell 1964, 504) saw as normal when the teacher can only alter instructional procedure, relocate curriculum content within a teacher group, and following recent training introduce special courses. (Hoyle 1968, 389) expressed a similar view "Within his classroom the teacher has a high degree of autonomy if not over what he teachers at least how he teaches it, but in terms of the overall policy of the school he has relatively little influence."

4.3.5.5 To function as a role-hybrid retraining may be involved. (Johnson 1964, 178) suggested "participants are paid for attending, a recognition of the importance of the task to which the teacher has been called." (Brickell 1967, 405) went further and suggested that to encourage staff not only should they be paid for time at the meeting, but also meals and travel incurred and salary credit for training. These were more positive steps than those given when (House 1974, 75) noted the work of Cohen which suggested that the informal reward structure can increase morale and job satisfaction, a similar point being made by (Peterson and Emrick 1983, 224). (Munro 1977, 59) writing of a C.E.R.E. report referred to a lock of understanding of the in-built reward and punishment structure. (Nicholls 1983, 88) saw those teachers with special skills adopting a leadership function and gave an ominous warning "If they are not able to do so there is always the danger that those activities might be undertaken by agencies outside the school. In these circumstances teachers would become no more than technicians carrying out the ideas of others, with Head Teachers acting as adminstrators."

4.3.5.6 There is evidence given earlier that the resistor role needs to be questioned. A measure of interest was expressed by teachers in the way in which they do attempt to assimilate innovation. (Anderson 1979, 77) suggested that "local information is not available nor is innovator interested in local practise." (Johnson 1964, 177) went so far as to suggest that local factors should be taken into acount in legislation, and wrote (p.179) "Consideration of flexibility demands that each school district be provided freedom to proceed on the process of change at its own rate." (Mort 1964, 326) and (Berman and McLaughlin 1975 and 1977 and 1978) also noted the importance of local effects. (Kohl 1981, 11) in reference to new schools wrote they "can also be orientated around the development of knowledge of the local community." (Louis 1983, 82) noted that the emerging demands in such an instance will probably not be met.

(Munro 1977, 53) was not in absolute agreement with Anderson stating "several projects have emphasised the need to match the function of schooling to different settings", he criticised the 'A' level Biology and 'Maths for the Majority' for not looking outside the school context. It was noteworthy that Munro mentioned that materials could not be teacher proof as the "specific situation" was significant whereas early Nuffield projects were orientated to the production of packaged materials.

4.3.5.7 Another criticism afforded by teachers was that of language. (Olsen 1977) pointed out the need to see teacher problems in teacher language. (Nicholls 1983, 74) referred to the comment of (Jackson 1968) on the conceptual simplicity of teachers talk. (Taylor 1982, 55) wrote "We have paid too little attention to the language teachers use." (Beauchamp 1963) found "no logical and consciously identified set of constructs behind the language being used by curriculum workers". (Munro 1977, 50) referred to the work of Core and Schroeder to make a similar point "....writings were often incomprehensibly biased in their presentation or of a limited applicability." An example of this was (MacDonald and Walker 1976, 12) writing of "a consensual process of melioration under benevolent overarching management."

4.3.5.8 (MacDonald and Walker 1970, 49) suggested that to survive, a project must have:

i) a 'non-divisive' view of the curriculum needs of the pupil;
ii) a high estimate of the ability of the low-achieving pupil;
iii) a fully articulated theory of pedogogy in its control area;

iv) a new curriculum that embodies the 'latest' conceptions of the subject held by University scholars.

They suggested that such conditions would satisfy educational establishments, educational sociologists and philosophers, also subject specialists.

But what of the teacher with his divisive local needs, lack of resources, skills and knowledge? Olsen doubted whether the presentation of innovation in working parties was effective: "discussion was not an educational construction familiar to Science teachers." (Nicholls 1983, 19) wrote "A more practical problem .... was that of limitation of technical skill in course construction" and "teachers gave no attention at all to the educational principles underlying the major dimensions of the innovation." (Whitehead 1980, Chap.7) identified many of these problems in the Humanities and General Studies Schools project: "teachers are not used to the idea of stating objectives nor do they have appropriate training." "Lack of observation and assessment techniques necessary before individual pupils can be 'matched'", "it should not be possible to ignore those sections of the unit which are particularly closely related to the project", and the curriculum package "should adequately and correctly reflect project philosophy."

The curriculum package as was stated previously must be 'sold' in advance and relate philosophy to practise. If this was not done then teachers may over-emphasise familiar components: (Brickell

1971, 405). With the various deficiencies noted it was not surprising that it was often reported teachers buy the materials but not the concept. (Nicholls 1983, 15) referred to a lack of rigour and superficiality. (Paterson and Emrick 1983, 226) made a similar comment drawing on the work of (Stearns M.S. et al 1975 and 1977). (House 1974, 71) referred to delay in adoption even though time-tabling is provided and (p.78) to the tendency of staff to "transform program intents."

4.3.5.9 The challenge of the expertise of the central team can be daunting and even if the innovation was accepted by the teacher once the novelty has worn off there is a reassurance in reverting to familiar established processes, similarly if funding was removed. Those staff, who were attracted to a project as an escape from a boring job or domestic circumstances may find the project stimulating and exciting at first. (Whitehead 1980, 11) reported that trial teachers may find greater involvement in schools other than their own; a natural escape from boredom. However, the attitude of such staff was hardly likely to influence the long term effect of innovation in terms of their in-depth/influence on expectation and relationships within a school: (Malone and Crone 1978, 84).

4.3.5.10 Various works reviewed by (Nicholls 1983, 44) suggested that there were two types of teacher in terms of decision involvement; obviously those who have lowest job satisfaction and opportunity to be involved in decisions may find attractions in projects. (Olsen 1980, 2) drew on the work of Sieber who identified three types of teacher:

i) rational, uses the best information available to form a decision;

ii) co-operator, only needs to be shown a direction;

iii) powerless, inert and must be instructed.

and the work of Doyle and Ponder who described three similar types: rational, pragmatic sceptic, and obstructionist. On the basis of this work (Olsen 1980, 2) proposed that any approach should recognise negative inducements to change and be based on a combination of these three types to suit all teachers.

4.4 SURVEY OF IMPLEMENTATION STRATEGIES TO THE LATE 1970'S

4.4.1 (Miles 1964, 2) wrote "A very wide variety of strategies for creating and controlling educational change is being employed - polemical, manipulative, technological, prestige -based, experimental, moralistic - with varying degrees of success." Of these strategies he broadly identified, (p.655), those as good which allow the teacher autonomy, freedom, involvement and spontaneity; and those as bad which involve newness, ambiguity, and unrealistic goal. It is significant that (Miles 1964, 648) was aware that a strategy may cause further innovation beyond the goal, especially as the mechanism of new feedback and added counselling become mechanisms of potential change.

(Miles 1964,) gave six types of intervention:

i)	Team teaching,	- the whole team outside of the school setting discusses a problem to improve working relationships.
ii)	Survey feedback,	- with the purpose of improving attitudes and opinions.
iii)	Role-workshop,	- staff of equal status meet and discuss their role on the basis of questionnaire data.
iv)	Target setting,	- the Head and individual staff meet, say six monthly.
v)	Organisational diagnosis	- the team in a residential setting discuss specific problems.
vi)	Organisational experiment	- following an innovation trial data is evaluated to formulate further policy.

Later (Miles 1965) introduced the term 'organisational health' to describe how receptive a school environment was to innovation. The emphasis was on strcuture not people: goal focus, communication inadequacy, optimal power equalisation, resource utilization, cohesiveness, morale, innovativeness, autonomy, adoption and problem-solving capacity. (Stenhouse 1975) suggested these dimensions had a non-reality, he was doubtful if innovative schools had clear goals: (Holt 1980, 105).

4.4.2 (Rogers and Shoemaker 1971, 22) implicitly provided a strategy when they gave five factors which applied to the acceptance of an innovation:

i) Relative advantage	-	what benefits are there economically, socially etc., is the innovation better than what existed previously?
ii) Compatibility	-	is the innovation consistent with those values acceptable economically, socially, professionally etc?
iii) Complexity	-	to what degree is the innovation difficult to understand and use?
iv) Trialability	-	can the innovation be tried out in its separate parts?
v) Observability	-	are the results of the innovation visible to others?

These models of strategy were as deficient as were the models of innovation of the same period, (4.2.1), and as evidence was evaluated from work initiated throughout the 1960's, more sophisticated observations emerged in the mid 1970's.

4.4.3 (Rudduck and Kelly 1976, 98) isolated four factors in the dissemination process:

i) Translocation: the movements of people and materials necessary to implement new aspects of the curriculum;

ii) Communication: how information about an innovation is transmitted from one person to another;

iii) Animation: the need to arouse teacher's interest in the project, and to provide some motivation for them to involve themselves in it;

iv) Re-education: implies that considerable understanding and committment are required in the effective implementation of an innovation.

Writing in 1976 Rudduck and Kelly surveyed earlier strategies and experience, reaching the conclusion that 'Re-education has seldom been achieved, and that only recently has the importance of motivating teachers been appreciated. They considered that past neglect might be accounted for by concentration on changing the content of the curriculum. Emphasis now centred on the need for changing the way in which the teacher performed his role, since most new projects involved him in many unorthodox teaching techniques and other classroom activities.

4.4.4

In addition Ruddick and Kelly divided the dissemination process into three time phases:

i) Receptivity - likened by Whitehead to a softening up process.

ii) Adoption - the project is taken up, its new ideas are received.

iii) Implementation - how the project is used in practise, how the innovation is maintained.

These phases were described as being complementary to the components of dissemination eg. Receptivity.

4.4.5 (House 1979, 8) referred to later work of Rudduck in which she saw dissemination as the meeting of two distinct cultures, the research population and the teaching population. (House 1979, 9) also referred to Wolcott, who divided the population into technocrats and teachers overlapping in a 'moiety' system. Wolcott saw the two groups as exhibiting complementarity, reciprocity, conceptual antithesis and rivalry.

The teacher culture was means orientated and

i) Teachers are autonomous

ii) Teaching is sacrosant

iii) Only teachers understand teaching

iv) Teaching has a tradition not easily changed

v) Teachers are vulnerable

The Technocrats were ends orientated; and information, rational planning, projects, management setting and command knowledge were valued. Many of these factors were implicit in Pitmans extended negotiation model, (4.4.3), and identify with on the one hand the conservative attitudes of teachers to innovations, (4.3.5), and on the other of failure of the technocrat to be able to effectively and efficiently communicate with the practitioner.

4.4.6 (MacDonald and Walker 1976, 40) concluded "the myth of receiver has been nailed." They considered take-over bids for the social system would fail giving two reasons:

i) the take over strikes at the self esteem of those to be co-opted.

ii) power is distributed more widely than those at the centre realise.

4.4.7 They made three propositions (p.42) about Curriculum Negotiations: propositions which (House 1979, 6) described as an original contribution.

i) Projects are subordinate to the school system and can only seek their ends within the limitations and constraints of that system.

ii) Projects engage in image manipulation in order to disguise discrepancies between their own educational convictions and the convictions held by others, particularly teachers on the one hand and academic critics on the other.

iii) There is a constant generation of two distinct and conflicting views held outside a project concerning what the project actually 'is', one view is held by teachers, the other by critics, concerned with the way an innovation is to be introduced. Further they observed:

iv) The so-called gap between intent and practise is in part a function of the differences between these two views of the project. The gap is therefore partly planned.

v) The process of curriculum dissemination, in so far as it assumes a stable message, does not occur. The process to which the term 'dissemination' is conventionally applied would be more accurately described by the term 'curriculum negotiation'.

4.4.8 (Pitman 1981) suggsted that the MacDonald and Walker negotiation model needed to be extended as changes should be looked for not in the teacher but in the student subjected to the innovation, also it should be recognised that the developer and teacher have different motivations. The use of the term 'developer' by Pitman to replace 'innovator' more frequently used by other authors suggested that the centre functioned as a team with division of labour. (Rogers and Shoemaker 1971) had described 'change-agents' and 'opinion-leaders' in a somewhat similar complementary role. Pitman required negotiation to take place otherwise the teacher would intercept the message, imposing their own philosophy; (Nicholls 1983, 14) suggested that innovations as determined within a school would have a "lack of rigour".

Four types of negotiation are described:

i) Dis-equalisation, - essentially a range of options are offered so that in accepting one of these the practitioner has a closer identity with what is to be put into practice. Acceptance is facilitated by more contact.

ii) Swamping, - essentially in giving too much emphasis on an issue, 'overkill' occurs and the practice may be adopted on the basis that it can be identified to the problem as perceived.

iii) Conciliation, - in this form the basic differences in stance are avoided so the practictioner takes away a superificial adoption.

iv) Suppression, - this involves a refusal on the part of the practictioner to accept any part of the proposal.

4.4.9 (Chin and Benne 1976) identified three groups of strategies, considered by (Hoyle 1970, 3) to be similar to those of other writers on the subject.

i) Empirical-Rational Strategies, an agent assumed to be aware of the receiver circumstances and of the possible effects of an innovation communicates to a receiver assumed to be both rational and capable of reacting. This simplistic approach assumed knowledge is power, it took no account of behavioural changes required and needed strengthening by improved general education, choice of staffing, applied research, and linkage system. These suggestions and the concept of a systems analyst as Staff Consultant were thought by (Nicholls 1983, 29) to have problems in relation to innovation in schools. (Hoyle 1971, 392) saw the consultants concerned with content rather than the mechanisms and processes of change especially as this applies to schools.

ii) Normative Re-educative Strategies, when identified with an innovation this strategy changes in social constraints and the concept of the "socio-cultural norm" (Chin and Benne 1976, 23) wrote ".... changes in normative orientations involve changes in attitudes, values, skills, and significant relationships, not just changes in knowledge, information or intellectual rationales for action and practice." (Hoyle 1971, 392) identified two approaches to this strategy: a problem solving method examined the situation from outside to determine how the system behaved, the alternative method required more involvement with the system to determine how ones development would impinge on the system.

(Nicholls 1973) thought that the use of school based in-service education and external consultants might make this strategy more acceptable, but she dealt particularly with the spirit of the approach. Of the approaches to this strategy she wrote (p.31) "Both emphasise experience-based learning as a feature for all lasting changes in human systems, and both accept the principle that people must learn to learn from their experience if self-directed change is to be maintained and continued." The innovator was being called on for certain features, (p.31): "Openness of communication, trust between persons, lowering of status barriers between parts of the system, and mutuality between parts." These and other factors make this strategy "more difficult, complex, and time consuming" and consequently not widely applied. (House 1979) described a model of a technocrat with his management setting and command knowledge; the use of the Normative-Re-educative strategy would certainly afford a challenge to such a person.

iii) Power-Coercive Strategies, such strategies according to (Nicholls 1983, 32) "emphasise political and economic sanction and the use of moral power playing on feelings of guilt and shame." Chin and Benne considered that such strategies were widespread and not always perceived by those out of power.

(Nicholls 1983, 32) gave references to the use of this strategy in schools in spite of current thinking about staff employment. (Brickell 1971, 503) made a somewhat similar point when he wrote "The language used almost universally in discussing administration - 'shared decision making', 'the team approach', 'full staff involvement' was not descriptive of the actual process. More often than not these euphemisms were intentional disguises."

(House 1979, 11-12) thought that the early innovation process saw teaching as a craft and that later a technology role was identified. He suggested that for those who see teaching as a craft, political controversy over their role and function was unavoidable, whereas the technolgist became involved in the controversy of the evaluation and organisational structures. The controversy, he suggested required "coercion and pressure, bargaining, and compromise."

Writing of Power-coercive strategies (Hoyle 1971, 392) stated "But within education there is a strong sentiment against such strategies founded on the assumption that because of their very nature educational ends cannot be achieved without the committment of the participant, both teacher and taught." This latter reference to the 'taught' is significant as it is made in 1969 and is currently relevant in 16+, FE etc., proposals concerning curriculum.

4.5 CONCLUSION

The Schools Council at an early stage recognised the need for in-service training, provision of liaison staff, setting up of local centres and the need for alterable and on-going evaluation of the dissemination. These features and the tendency of management models to include Social Interaction and Periphery-Centre modes to be implemented by means of appropriate strategies could significantly achieve many of the purposes of innovation. However, as (Rudduck and Kelly 1976, 103) noted when referring to models and their hybridisation "This is not to say that such theoretical issues play a large part in official thinking."

SECTION 5. CENTRAL CONTROL AND RATIONALISATION;

(Havelock 1969,) wrote "....the government should be in a position to see one system. Government capacity to monitor whole, check on standard of research, development and diffusion..."

This section describes how the D.E.S. achieved it's pre-eminence over L.E.A.s and teachers, in matters of educational policy; also how the D.T.I. became increasingly involved in education and training. The activities of both D.E.S. and D.T.I. are shown to offer the Central Control described by Havelock and the impact of their policies is described. A brief account of the rationalisation of examination provision is given as this is relevant to changes in syllabus structure which are still to be announced.

5.1 FAILURE OF THE TRIPARTITE CONTROL OF THE CURRICULUM 1972 - 77.

5.1.1. CRITICISM OF EDUCATION PROVISION.

(Richards 1978, 1) wrote of 1963-73 as being a 'golden age' for education, "there was an emphasis on innovation, enterprise, autonomy, and diversity fostered by belief in the value of education for economic, social and intrinsic reasons." This period which could be said to have begun with the launching of Sputnik I, October 1957, ended abruptly with the oil crisis and it's economic consequences in 1973. Other factors such as falling rolls, unemployment: (Salter and Tapper 1981, 192), parental pressure, unanswered problems of inequality and underachievement: (Chessum 1980, 115) and political philosophies combined to question the attitudes of the 'golden age'. According to (Richards 1978) "... awkward questions have been raised about the role of education, the effects of curriculum reform, the intervention of central government, the desirability of teacher autonomy, the significance of 'hidden curriculum", and the supposedly non-political nature of education in general and the curriculum in particular."

Criticisms of the curriculum implied in the famous phrase made in 1960 by David Eccles about the 'secret garden' of the curriculum could no longer be ignored. (Weaver 1979, 67) writing of Policy Analysis and Review noted the new 'machinery', "led, in 1971 and 1972, to a wider and deeper re-appraisal of education policies than the Department had ever previously attempted." (Salter and

Tapper 1981, 194) indicated that "By 1975 something of a gap had developed between the implications of the D.E.S.'s internal planning arrangements and the reality of it's external power or lack of it." Various writers made reference to the significance of the 10th Report of the House of Commons Expenditure Committee which (Lawton 1980, 24) maintained was produced "... partly as a demand that Education should give value for money but partly as a criticism of the fact that D.E.S. appeared to condone the view that teachers alone should have control of the curriculum." Further criticism of the D.E.S. for not being open in it's dealing was made by a 1976 Select Committee: (Kogan 1978, 119).

In 1976 the Prime Minister, James Callaghan, in his Ruskin College speech drew attention to the failure of the Secondary School Curriculum, its failure to innovate and especially the failure of schools to encourage students to continue on to study in the sixth form. Not surprisingly industrialists such as Weinstock and Meltoer now commented publically on the education system, whereas previously comment was made privately: (Ahier and Flude 1983, 225).

Following the various criticisms the D.E.S. abandoned its previous passive role (Holt 1980, 9) and according to (Salter and Tapper 1981, 39) "... ever since the D.E.S. has led to a purposeful quest for a new experience of schooling geared more closely to the needs of the labour market." The appointment of James Hamilton as Permanent Secretary marked the beginning of this changed role: (Hammersley and Hargreaves 1983, 46-47) in which the D.E.S. used its power (Weaver 1979, 22-24) to establish its pre-eminent credibility partly by destroying the credibility of its esrtwhile partners in the golden age.

5.1.2 THE 'UNDERMINING' OF THE L.E.A.s

A request, D.E.S. 1978a, was issued to L.E.A.s in November 1977 for information of L.E.A. education provision. This led to a 'Report on the Circular: D.E.S. 14/77' in 1979; writing in the foreword to this report the Secretary of State observed, "The Government is deeply committed to the maintenance and improvement of educational standards in the schools. This does not mean looking for more resources, which are not available, but getting better value for the resources which can be afforded. Concern about educational standards can not be divorced from concern about the curriculum offered." This D.E.S. review revealed that although 70% of the L.E.A.s retained central funds for curriculum development only 20% were able to provide limited funding for projects and only 40% referred to actual work on science etc. Whether the poor picture was a consequence of the Local Government re-organistion in 1974: (Hunter 1983, 100-101), was speculative; the report did however afford an opportunity for a central control: (Pile 1979, 236).

Further opportunity of central intrusion was offered when the L.E.A.'s found it would be inefficient for them to face individually in isolation the common problem of future educational provision 16-19: (Ahier and Flude 1983, 72), and they sought a central solution leading to the (MacFarlane Committee Report 1981). The Secretary of State used his power relative to that of the L.E.A.'s: (Weaver 1979, 38-39) also (Pile 1979, 29-30), in line with the foreword mentioned above, and "MacFarlanes keynotes were rationalisation, resource management and cost-effectiveness": (Edwards 1983, 61).

The White Paper of March 1981 'The Government's Expenditure Plans 1981-2 to 1983-4' stated "The Government remain committed to the objective of maintaining and improving the quality of education." For 'standards' in 1979 read 'quality', in 1981 an interesting amendment in view of socio-economic changes. The White Paper also mentioned financial restrictions suggesting that education ".. can serve as the foundation for further educational development and improvements, not all of which need more resources." Sir Keith Joseph was more explicit on this point in January 1982: (Hunter 1983, 93-4).

In response to falling rolls and the avoidance of duplicating small classes with specialist Staff, Manchester proposed a scheme involving sixth form Colleges and Further Education (F.E.) which was envisaged to develop into a Tertiary System. This was rejected by Sir Keith Joseph as "only in exceptional circumstances can it be right to reduce good schools from 11-18 to 11-16." As (Edwards 1983, 73) observed the decision contradicted MacFarlane's support for treating 16-19 provision as a totality. Shortly afterwards the Croydon Tertiary proposals were rejected as the remaining 11-16 schools were considered too small for appropriate curricula and sufficient teaching groups. (Hunter 1983, 97) wrote "By siding with particular local interests against the elected Authority the Secretary of State undermines the Authority, and therefore it could be argued diminishes the reponsibility of Local Government. It is an example of 'centralism' with the D.E.S. or Government taking on more responsibility and negotiating local decisions when it suits them."

5.1.3 THE DEMISE OF THE SCHOOLS COUNCIL

The Schools Council comprised a tripatite structure involving D.E.S., L.E.A.s and Teachers providing the teachers with a legitimate authority in matters affecting the curriculum etc. However, whatever authority the School Council had was weakened by its own 1978 Report which:

i) criticised the R D and D model, (4.2.8.1), which was the model adopted by the Schools Council for many of its projects.

ii) Showed that features of its own 1972/73 report were still not implemented. The Dissemination phase widely held to be important: (Whitehead 1980, 58) was added to the Humanities, General Studies Schools Project (H.G.S.S) as late as 1984.

Many other factors contributed to the declining influence of the Schools Council:

i) In the Black papers (Cox and Dyson 1971) the Schools Council was associated with progressive methods when there was a growing call from many for a return to the '3R's': (Dcle 1983, 242). (West 1984, 182) considered that the complaint of falling standards 'never stuck' and he attributed the problem to a lack of definition of curriculum aims and objectives. (Salter and

Tapper, 1981 119) commented that the constitution of the Schools Concil outlawed such concepts as 'intervention' and 'direction' and (Becher et al 1981, 146) showed that in the face of criticism the Schools Council found solace in their 'professional wisdoms'.

ii) The Schools Council was identified with teacher unions and teacher politicians and their petty policies by several writers: (Kogan 1978, Chap.6) and (Becher et al 1981, 147).

iii) The organisational structure of the Schools Council was weak. (Galton 1970, 139) identified a weakness insofar as the election of teachers onto the Council was via the official unions and professional organisations. (Mann 1979, 127) stated that the diffusion strategy was 'cumbersome' and 'ill-designed' to gain co-operation at a time of rapid change. Other writers such as (Salter and Tapper 1981, 125) suggested that by making appointments on short term contracts that any advantage of fresh-blood was far outweighed by a failure to accumulate expertise.

iv) Since 1964 the Schools Council was committed to broaden the sixth form, yet its Q and F proposals were found unacceptable in 1969, and its N and F proposals were dropped in 1979 (Holt 1980, 48-52 and 166-168), (Kelly 1982, 124) wrote of the limited effectiveness of the Schools Council in promoting curricula change, and when it did encourage change it was criticised for the use of policies which could lead either to indoctrination: (Kelly 1982, 125-7) or to an extension of teacher power through the use of Mode 3 examinations (Whitty 1983, 170-71). In fact the control of C.S.E. examinations was effectively in the hands of "... senior members of the professions rather than a major devolution of power to teachers on the class-room floor":

(Whitty 1983, 168) and Whitty suggested that Mode 3 was relatively conventional rather than subversive. Nevertheless the C.S.E. was not considered an effective means of curriculum control (Hurford 1979) and there was criticism of teacher-assessment from Universities and traditional University based G.C.E. boards which extended into a further criticism of teacher autonomy: (Whitty 1983, 176); (Bowe and Whitty 1981, Chap.11).

(Pile 1979, 99) wrote of examination and curricula aims at 16, "This was a problem that could only be tackled by a body with a wider remit than the supervision of examinations" and the reponsibility for developing a new common system of examining was not given to the Schools Council: (Holt 1980, 140).

iv) The Schools Council was an easy target for financial saving.

Many of the criticisms were moderated as being made either in hindsight: (Kelly 1982, 127) or without regard to the valuable practises stimulated by the Schools Council: (Lawton 1980, 160); indeed many of the Schools Councils initiatives such as the proposals for sixth form review made in 1972 were later followed through. (Holt 1980, 182) summed up the activities of the Schools Council as either doing the right thing at the wrong time or the wrong thing at the right time.

The Schools Council announced its own intention of a constituted review: (Mann 1979, 128) but in effect Shirley Williams initiated a review in 1977-78. This led to a reconstituted Schools Council in 1978 and new guidelines in 1979 so that the Government and the L.E.A.s had the greatest control as they dominated the influential Financial Committee. (Varney 1985) described how the Trenamane inquiry, announced in 1981, criticised the Schools Council but suggested no further review for five years. However, within a short time the Schools Council lost its status and the Schools Examination Council (S.E.C.) and Schools Council Curriculum Review were formed; the latter continuing the policy of the Schools Council of moving from national projects to local curriculum development: (Salter and Tapper 1981, 126).

5.1.4 THE TEACHERS STATUS IS WEAKENED.

The status of techers relative to the D.E.S. and the L.E.A. in curriculum control was weakened by the D.E.S. initiatives against the Schools Council. (Salter and Tapper 1981)[1] also made several references to how the teachers unions were outmanouvered by the D.E.S. Other writers such as (Mann 1979, 127) and (Holt 1980, 132) described how the teachers case was weakened as they did not take a sufficently wide view to form their judgements. This decline in influence was not opposed by the public who at that time identified teachers with the findings of the (Auld Report 1976) into the William Tyndale School.

(Salter and Tapper, 1981, 209) described the further erosion of teacher power when the Taylor Report (the Composition of School Governing Bodies 1977f) was issued. In F.E. Sector (Cantor and Roberts, 1979, 22-3) considered that the creation of Governors

1. (Pages 54, 62, 208, 224)

weakened the Principals role and the formation of an Academic Board weakened the role of the L.E.A. However, the changing membership of the Academic Board allowed the Principal to take the initiative and the L.E.A. retained a financial control.

5.2 THE GREAT DEBATE AND IT'S AFTERMATH.

5.2.1 THE ROLE OF THE D.E.S.

The changed role of the D.E.S. became more evident following release of the 1977 Yellow Book and the 1977 Green paper, and the ensuing Great Debate. Basically the D.E.S. sought for:

i) an increase in the work of the Assessment of Performance Unit (A.P.U.), a unit set up in August 1974 and criticised by (Lawton 1980, Chap.4) because of its secrecy. A measure of its low profile was that (Pile 1979, 103) noted "an extensive programme of research" but never mentioned A.P.U.

ii) financial control as afforded by the Training Services Agency (T.S.A.) and Manpower Services Commission (M.S.C.).

iii) a common curriculum core.

Ten regional conferences for selected audiences were held in 1977 followed by the issue of the Red Book 1977, in which reference was made to the eight areas of experience to be included in the curriculum.

(Lawton 1980, vii) wrote "there are faint but discernable signs that D.E.S. is attempting to exert more central influence". He saw (p.9) the 1977 Green Paper and the Red Book as suggesting a desire from the centre for control of the curriculum. Within the climate of opinion created by the Great Debate. (Salter and

Tapper, 1981, 41 and 91) stated that D.E.S. was prepared to state its own view as in 'A framework for the School Curriculum 1980', and then gauge the reaction before modifying their perspective to 'The School Curriculum 1980'. Both documents were considered to be significant as they offered definitive guidance on the curriculum: (Kelly 1982, 239) and they put down in 'black and white' several important statements including that there should be a core: (Kogan 1984, 129). (Salter and Tapper 1981, 34) noted the "... repeated pronouncements to the effect that school should serve the needs of industry more effectively", a policy viewed by (West 1981, 229) with strong reservations.

5.2.2 THE INSPECTORATE.

The H.M.I.'s who in Curriculum 11-12 had accoding to (Kogan 1984, 129) argued the case for a common curriculum with not too many options as they ".. may prevent the right of access of pupils to certain kinds of knowledge", in 1980 issued 'A view of the Curriculum 1980'. Whereas the former document was criticised as it did not appreciate the practical aspects of the whole curriculum innovation: (Holt 1980, 49-50), Kogan thought the latter document perfectly sensible.

Other writers such as (Salter and Tapper, , 231-2), (Broadfoot 1983, 254-258), and (Becher et al 1981, 149) described the H.M.I. publications as a continuity of theme leading to a situation in which a dominant D.E.S. could specify curricular policy. However, (Kogan 1978, 139) thought the "D.E.S./H.M.I. would be reluctant to take centralization too far", a view repeated:

(Kogan 1984, 124) when he wrote ".... fears of a strong prescription are exaggerated." The latter view was obviously shared by the Schools Council as in the introduction to Working Paper 70 'The Practical Curriuculum', they noted the Government "... did not intend to alter the statutory relationship between the various partners."

5.2.3 CRITICISM OF THE D.E.S.

Although the D.E.S. was successful in damaging the credibility of the Schools Council, L.E.A.'s and Teachers it was itself open to criticism because of delays in policy implementation etc.

i) (Holt 1980, 7) noted that while the D.E.S. criticised the Schools Council, the D.E.S. was substantially represented on the Schools Council committees.

ii) The Plowden recommendations were not made obligatory until after a 13 year delay when the 1980 Education Act was passed: (Becher et al 1981, 41).

iii) (Cantor and Roberts 1979, 13) commented on the 4 year delay after the report from the 1969 Haslegreave Committee before setting up the Technician Examinations Council (T.E.C.) and the Business Examinations Council (B.E.C.).

Similar comment was made by (Moor et al 1983, Chap.1).

iv) (Weaver 1979, 84) gave a list of D.E.S. ad hoc working parties which showed that since 1970 their findings were often never implemented.

v) The M.S.C. in 1977 were able to seize an initiative in 1977 with the publication of the Holland report which led to the Youth Opportunities Programme (Y.O.P.); (Salter and Tapper 1981,

204) described the D.E.S. as needing protection from further encroachments and a strong platform for lauching co-operative ventures. A previous co-operative venture led to a pilot Unified Vocational Preparation Course in 1976 which flopped due to employers apathy and reluctance to accept costings.

vi) (Cantor and Roberts 1979, 179) criticised the D.E.S. for allowing F.E. to drift before taking account of an internal review: (Hammersley and Hargreaves 1983, 45-46) and setting up the Further Education Unit in 1977. Although it must be noted that in F.E. the H.M.I. always had a more prescriptive role than in schools: (Pile 1979, 138) and (Kogan 1984, 128).

5.2.4 THE D.T.I. CHALLENGE TO THE D.E.S.

The changing status of D.T.I. relative to D.E.S. can be traced from the 1964 Industrial training Act which led to the formation of Industrial Training Boards (I.T.B.s) for approximately half of the U.K. workforce. Subsequently following a Government review in 1972 a consultative document 'Training for the Future' was released which led to the 1973 Employment and Training Act. This legislation simplified the requirements of the earlier 1964 Act with respect to the levey system and the responsibility for administration costs. The 1973 legislation also resulted in the setting up of the M.S.C. in 1974 to oversee the Employment Services Agency (E.S.A.) and the Training Services Agency (T.S.A.). In the opinion of (Lewis 1982) since 1974 the Government's intervention led to changes in employment and training patterns and to programmes designed to smooth the transition from school to work.

One such programme was the Work Experience Programme (W.E.E.P.) introduced in 1976, this was to include a basic element in Life and Social Skills with either Literacy and/or Numeracy over a six month period. According to (Fiddy 1982, 20) the "weighty implication in W.E.E.P. is that there is a fault with the unemployed school leaver if he needs extra schooling to make him employable."

In 1977 the Holland report published 'Young People at Work' and in 1978 the Y.O.P. scheme appeared through a merger of the W.E.E.P. and Job Creation Programmes. The scheme was aimed at the unemployed under 19 years of age and cocentrated on the less well-qualified. A similar scheme was the Training Opportunities Scheme (T.O.P.S.) which afforded 1 year full-time training or re-training in Skill Centres, F.E., etc., for those who were employed or wished to change their employment. (Raffe 1981) thought the objectives of the schemes were in a large part educational writing "... the programme aims to enhance the skills and personality of employed young people and to compensate them for any deficiency in their education..". (Salter and Tapper 1981, 18) noted that many of the skills were "... perhaps of a more social than educational nature", and that the end result of the schemes was to close the gap in educational attainment of school leavers.

Further criticism of student achievement at age 16 was made in a 1978 report 'One Year Pre-employment Courses for Students age 16;'; this report also criticised the tangle of F.E. provision offered to such students.

5.2.5 A BASIS FOR CHOICE.

The F.E.U. was set up in 1977 and in 1979 'A Basis for Choice' (A.B.C.) was published. This continues to be an authoritive document on pre-employment and vocational courses which was cited approvingly by several organisations concerned with education: (Avis 1983,23). Avis described the A.B.C. curriculum framework for part-time 1 year education of pre-employment groups as being "aimed both to rationalise provision and to gain national currency for the qualification acquired from such courses." The criticisms offered by Avis were answered by (Mansell 1983, 34) who suggested that Vocational Preparation 1981, was nearer to what would be published now, this placed A.B.C. within the context of vocational preparation. Mansell wished to avoid student resistance by making a course relevant and he required profiling to emphasise success rather than the failure of alternative examinations.

Attention to pre-16 curriculum issues and the traditional separation of education and training was made in 'Foundation for Working Life, Education and Training 16-19' (Venn Report) issued 1980 by the Standing Council of Regional Advisory Courses. The Venn Report hoped that A.B.C. would rationalise the plethora of courses. Another report issued at the same time by the Secretary of State: 'Examinations 16-18' suggested the replacement of C.E.E. with a further education validated course as in A.B.C.

5.2.6 NATIONAL POLICIES

5.2.6.1 Thus the demands for vocational directions within the curriculum were increasingly made an in an economy where unemployment was rising, further policy ststements were soon forthcoming: On the 15th December 1981 two documents were published simultaneously.

i) National Training Initative: Programme for Action - a White Paper from the Secretary of State for Employment, this followed a consultation paper 1981.

ii) National Training Initiative: Agenda for Action - by M.S.C.

These documents were described by (Vincent 1983, 64) as an antithesis in spirit. The proposals of the White Paper were seen as another raising of the school leaving age (R.O.S.L.A.) and included some contentious financial implications for students and parents as well as a suggestion to develop an Open Tech. programme.

5.2.6.2 Following a report of M.S.C. in 1982: Institute of Manpower Studies Report 39 Foundation Teaching Issues there appeared to be three alternative strategies:

i) Pluralist, to allow a variety of approaches allowing the best to become obvious to the majority.

ii) Concerted incremented change of M.S.C. and I.M.S. proposals.

iii) Major Blue-Print, of which it could be asked 'is N.T.I. that Blueprint?

5.2.7 RECENT CHANGES.

After 1982 there was continued rationalisation of educational and training provision:

i) In 1982-3 seventeen of the twenty-four I.T.B.s were wound up on the basis that M.S.C. would be less bureaucratic and more cost efficient. Thsi also reflects a criticism of British Industry for its failure to modernise its training: (Maclure 1982, 109).

ii) In 1983 the various components of Y.O.P. and U.V.P. were merged into Y.T.S. and as a full-time counterpart to Y.T.S. a 17+ provision was formed: Certificate of Prevocational Education (C.P.V.E.). The C.P.V.E. was to replace the C & G Foundation Course, the R.S.A. Vocational Preparation Course etc., by providing a one year course of unified and specialised vocational preparation for students of modest 16+ exam achievements: (Edwards 1983, 67). This theme of rationalisation and provision of certification was in line with general changes in the schools sector and was encouraged to lead to the same syllabus for the common core: (F.E.U. 1982, 68), being course based rather than subject based, student centred and not formed. The changes were also in line with '17+ a New Qualification' produced by the Government in 1982 following the (Keohane Report 1979). Later in 1984 the F.E.U. considered th A.B.C. core for its use in a 17+ scheme. Both the A.B.C. and C.P.V.E. require recording and profiling rather than formal examinations alone and in the F.E.

sector B.T.E.C. had introduced profiling.

5.3 RATIONALISATION OF EXAMINATIONS.

5.3.1 THE 16+ EXAMINATION 'DEBATE'.

The Schools Council first proposed a 16+ in its 1971a publication making further mention in Bulletin No. 23; proposals for which (Holt 1980, 141) thought they should have got wider support. Another proposal made by the Schools Council that "... national criteria be established for syllabuses and assessment was endorsed by the Governments Waddell Committee in 1978. Consequently the Government issued a directorate to the G.C.E. and C.S.E. Baords Joint Council and the process of establishing a common 16+ was set in motion. Also in 1982 'Examinations at 16+: A Statement of Policy' was published, in which Ministerial approval of the national criteria was stressed.

Speaking in an address to A.S.E. in 1983, Sir James Hamilton, Permanent Secretary at D.E.S. said "... I am wholly prepared to use reforms of the examination system to bring about much needed changes in national attitudes towards curriculum." Two reasons were given for the 16+ review.

i) to rationalise the administrative procedures of the G.C.E. and C.S.E. examinations.

ii) To put some sense into a framework for curriculum and syllabus which had become increasingly convoluted and in many cases out of touch with the needs of the child, the parent, and the employer.

Note the second point had a vocational significance and it was not explicit about a common core whereas the 1977 Green paper referred to a 'core' or 'protected part'.

The procedure adopted for the 16+ debate was that groups of G.C.E. and C.S.E. Boards would prepare their own syllabuses to agreed guidelines. The drafts after consideration by schools would return to the original working party; parallel consideration was also made by the Schools Council and H.M.I.s (Kelly 1982, 195) criticised this process as it limited teachers influence and (Phillips 1982) suggested that the working parties did not consult widely perhaps due to constraining time demands. Phillips criticised the assessment style and the way in which working parties were formed writing, "experience or connection with examining boards seemed to be the only criteria for it's membership." This is not surprising as according to (Beck 1983, 226) the University dominated boards had successfully resisted the industrial lobby during the Great Debate and shown their resilience in the new phase. (Whitty 1983, 176-180) described how the G.C.E. Boards regained influence ceeded to the teaching profession during the 1960's. Whitty further described the Boards competing for favour by being seen to uphold standards through "the extension of increasingly dominant technical modes of control from the capatilist labour process into schools", especially tighter statistical control over Mode 3. Similar comments were made by (Bowe and Whitty 1981, Chap.11).

5.3.2 THE 16+ PROVISION.

Following the consultative process Sir Keith Joseph made a speech on 6th January 1984 which contained the following points:

i) The 16+ examinations would become criteria referenced.

ii) The School Curriculum should have breadth, relevance, differentation and balance.

iii) The minimum level of attainment in Science should include: observation, appropriate measurement, sensible prediction, a practical approach to problems, acting on instructions, following safety precautions, and effective communications.

5.3.3 G.C.E. 'A' LEVEL.

Although not as prescriptive at 'A' level as at 16+, the Secretary of State for Education did establish in 1980 the conditions of clarification and rationalisation of syllabuses for 'A' level G.C.E. (Adkins 1984) indicated that in the case of Physics these conditions will be adopted from 1985.

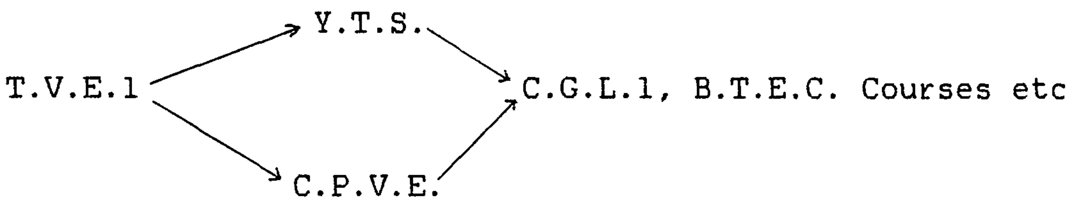
5.4 CONCLUSION

In consequence of the organisational changes described in this section the framework of examination provision changed; (Fairbrother 1984) in an account "with some speculation" attempted to identify a pattern in examination provision and he submitted:

i) An academic route,

G.C.S.E. grades 1,2,3 ⟶ A.S levels ⟶ A levels

ii) An alternative route to Adult working life,



An (A.S.E. Subcommittee 1985) identified a similar pattern in which ii) was subdivided into 'Prevocational' and 'Vocational'. Also it should be noted that the T.V.E.I. scheme will extend to include G.C.E. 'A' levels.

At present the view of the B.I.M. is that youngsters opt for Y.T.S. and a guaranteed minimum wage rather than continue a formal education, but there is a body of opinion which seeks a party of esteem between the C.P.V.E. and the Y.T.S. with a 21 hour provision for C.P.V.E. Any legislation to give parity will affect the range of courses being taken up by youngsters, this would be significant within the scope of this thesis as some C.P.V.E. schemes could include provision for the inclusion of Electronics.

SECTION 6. ELECTRONICS IN THE SYLLABUS

An outline is given of the factors affecting the curriculum, and the interrelationship between the curriculum and assessment. Reasons in favour of Electronics appearing in the Curriculum in some form are then discussed.

The changing form and content of Electronics syllabuses at 16+, 17+, and 18+ are described with reference to Section 6. In view of restrcitions of time and space the emphasis is placed on the A.E.B. and B.T.E.C. (previously O.N.C.,T.E.C.) examinations. The modular form of B.T.E.C. and the assessment techniques are described insofar as they are pertinent to proposals being made in T.V.E.I. schemes etc., Section 7. Features contributing to the growth and acceptability of these syllabuses are identified.

"The simplest schoolboy is now familiar with truths for which Archimedes would have sacrificed his life."
Ernest Renan in Souvenirs d'enfance et de Jeunesse (1883)

6.1 THE FORM OF THE CURRICULUM

6.1.1 Writing of the content and form of education in terms of social heirarchy (Lukacs, 1923) stated "knowledge is a product of interaction of man, reality and interest." Similarly sociologists in the modern tradition: Young, Esland, Keddie proposed that all knowledge was socially constructed; their reflexive perspective was that education was negotiable being essentially and necessarily political. "Thus rationality itself becomes merely a convention, and the rules of logic and argument are shaped and selected in accordance with the purpose of the argument or the intentions of the arguer": (Mills 1939) expressed the same view more briefly: the "rules of the game change, with a change of interest!"

6.1.2 The perspective of philosophies was described by Phenix and Hirst. (Phenix 1964) described knowledge as being organised into realms of meaning which were non negotiable. He identified nine generics which students were required to understand and employ, and he formed these generics into six realms: symbolics, empirics, aesthetics, ethics, synoptics, and synoitics.

Phenix considered that within the curriculum disciplines were rarely assignable to a single mode of thought or realm of meaning. (Eggleston 1977, 59) considered the concept of Phenix as that "of a real objective world which we can discover, clarify and make meaningful."

6.1.3 (Hirst 1965) identified forms on knowledge, and of understanding; his work showed that the case for a balanced curriculum was implicit so that children were introduced to various ways of knowing. The forms given by Hirst were: Mathematics and formal logic; Physical Science; Human Science (including History); Moral understanding; Religious form; Philosophy; and Aesthetics. Eggleston considered the work of Hirst as "one of the most coherent and highly developed theories of curriculum."

Writers such as (Eggleston 1977, 59) observed that Hirst's view may be too narrow, not allowing room for sub-groups and different abilities. Such a view is not consistent however, with Hirst's statement: "decisions about the context of courses can not be taken without special regard to the abilities and interests of students for which they are designed." Indeed, Eggleston himself included quotes (p.59), from Hirst vis "Mind is an instrument allowing individual to understand the fundamental nature of knowledge." and (p.58) writing of the use of the objectives approach "unique, no one formula being suitable for all achievements", "each individual result can not be pre-sepcified." Thus it would seem that Hirst's view would allow the view proposed by the sociologist (Holt J, 1976) that "children learn what they want to know!"

6.1.4 The relationship between the views of sociologists and philosophers was placed in a somewaht polar form by (Taylor 1971, 161): Diagram 6.1

Taylor suggested that the matrix defined a 'total intended curriculum' writing "at no one moment is the pupil experiencing more than part of it though through his educational career he may experience much of it."

The form of the curriculum offered by Taylor was an early represntation of the Social interacting school as advocated by (Musgrove 1968), (Eggleston 1977) et al. (Driver and Worsley 1979) used a similar polar form: Diagram 6.2.

6.1.5 (Eggleston 1977, 72) later suggested that the earlier polar curriculum theories were open to criticism and he offered a restructured perspective: Diagram 6.3.

6.1.6 Thus the socialogical-philosophical debate evolved into a debate about whole curriculum planning, a system approach rather than a subject approach such as those of the Schools Council and Nuffield. According to (Holt 1980, 176) "Instead of viewing the curriculum as the sum of subject combinations 'whole curriculum change' takes an organic holistic view.." (Holt 1980,85) suggested that a "common curriculum, unifying key curriculum experiences for all pupils is now acquiring normative states". Insofar as (Macdonald and Ross 1975) defined normative planning to be about deciding what ought to be achieved according to the prevailing value system, then Holt's use of the term normative in his comments on the common curriculum implies a

Diagram 6.1

Taylor: 'total intended curriculum' in matrix form

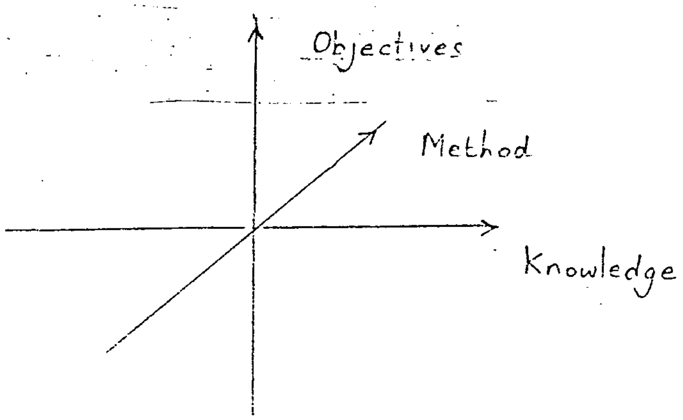


Diagram 6.2

Driver and Worsley: representation of curriculum

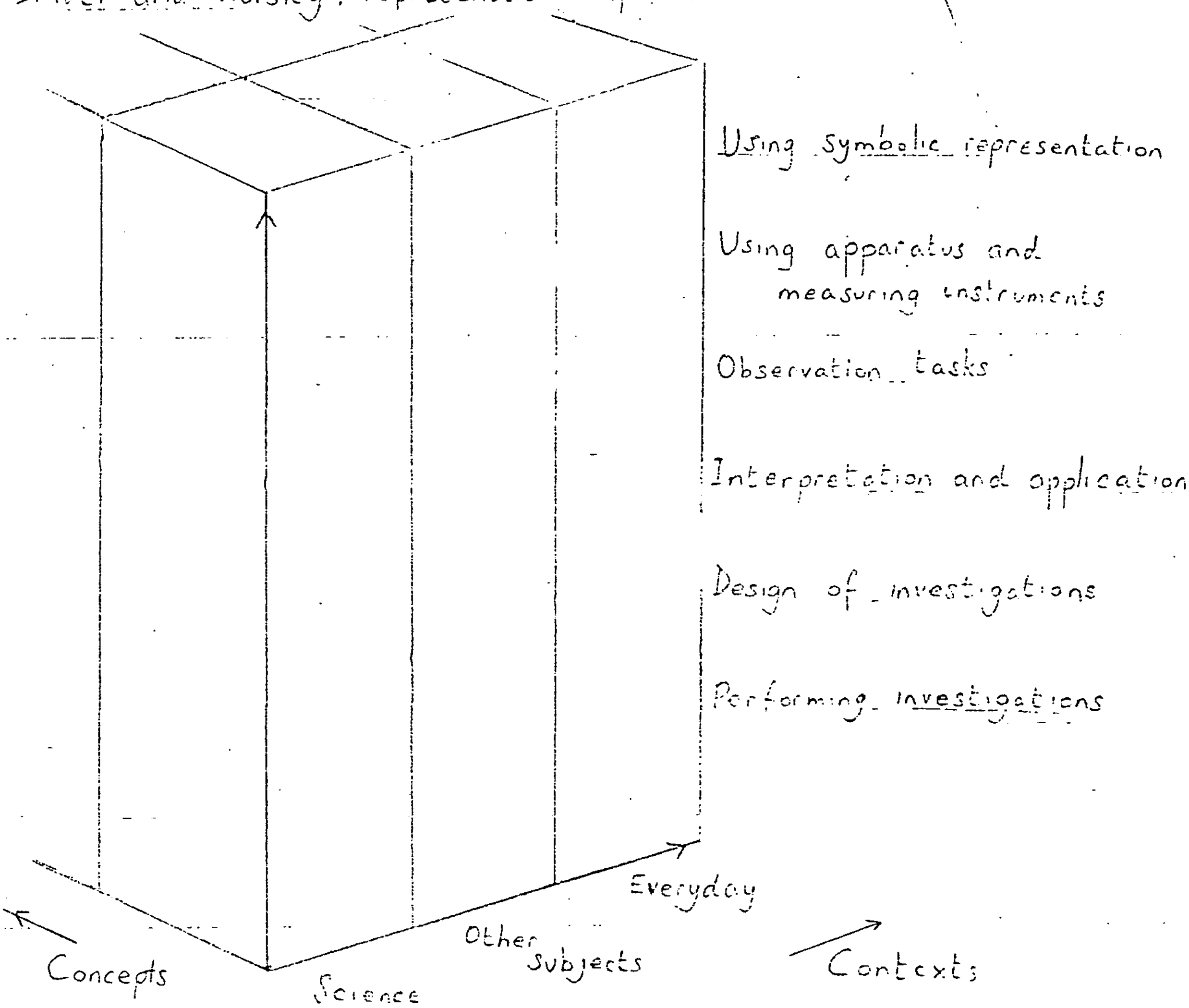
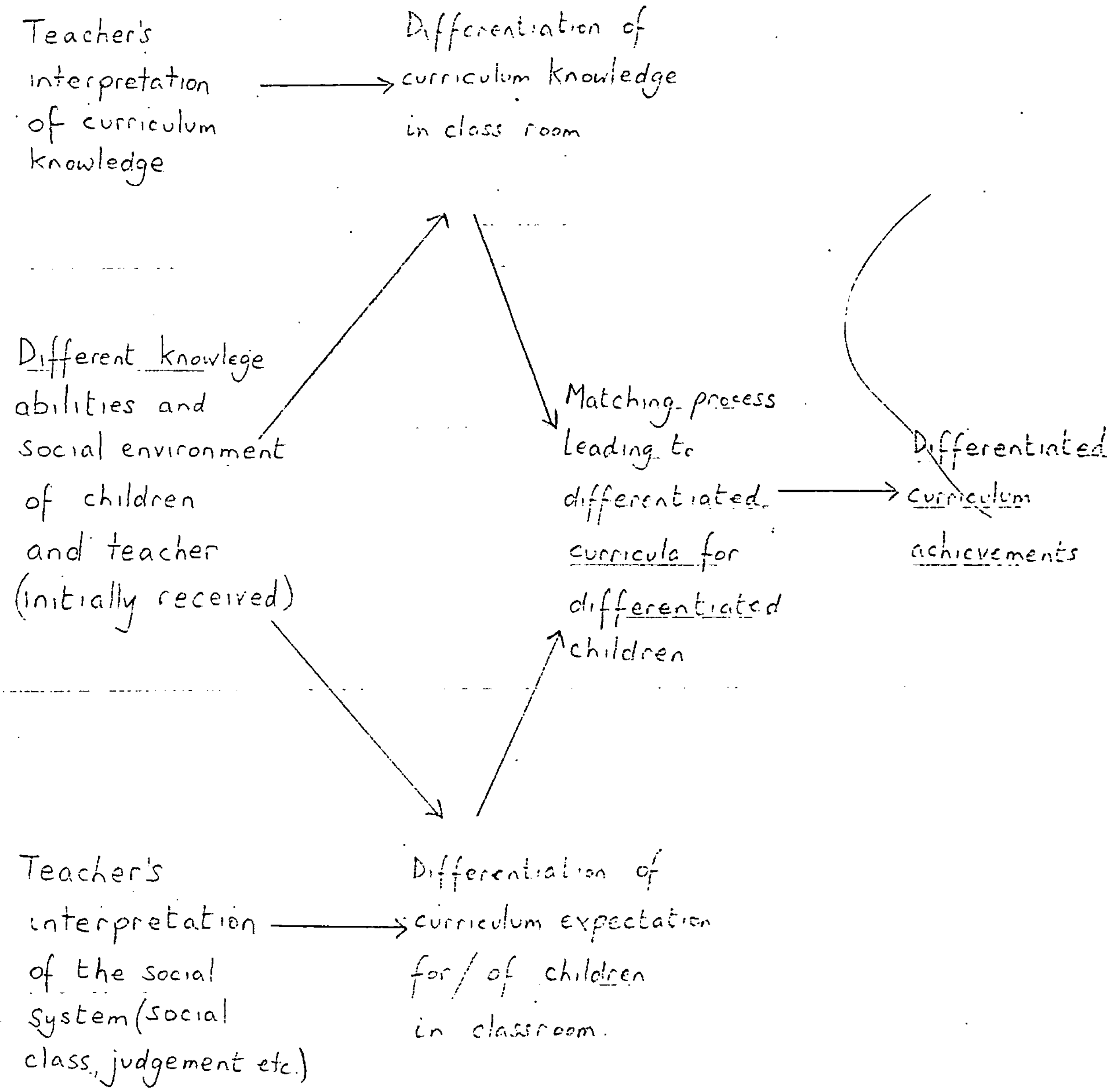


Diagram 6·3
Eggleston's: re-structured perspective of curriculum.



dynamic situation. Thus the various proposals for sciences as a core component of general education may be seen as attempts to keep pace with and to identify with the emerging views of whole curriculum planning.

(Kogan 1980, 130) wrote "But ultimately the curriculum is going to be a compromise between such traditional concepts as the accumulation of knowledge and cognitive skills, an ability to adapt to the needs of Society and work, the need for individual development, and the need to make sure that we are all part of a Society that becomes productive and well balanced again."

The point of compromise will itself change and Kelly warned against searching for "some once-for-all, God-given criteria". Indeed Eggleston considered that with improved storage and rate of change there would be a shift of emphasis of the individual from knowledge storage to a 'knowledge developer', others see the changes as requiring 'humanity' in each syllabus.

6.1.7 Writers such as (Taba 1962), (Kerr 1968) included evaluation in their models of curriculum planning whereas (Taylor 1971) did not. Recently (West 1983, 409) placed teaching and assessment in juxta portions:

Teaching/ Learning	Aims	- Objectives - Content - Pedgogy - Evaluation - Assessment
Assessment/ examining	Aims -	assessment objectives - Content - Technique - Assessment

Such a representation is suggestive of an Action-Reaction mechanism in Sciences eg. Inductive and motor effects. The latter are illustrated by Fleming's Right hand and Left hand Rules, these rules include mutually perpendicular axes such as those proposed by Taylor.

Thus Taylor's model could be complemented with a holistic mirror image of evaluation/assessment. As such traditional examinations are seen to be polar and the further development of assessment procedures complementary to the position of the curriculum core can be anticipated. (Cadd 1981) suggested a holistic appraoch to evaluation in which interviews were used to determine a behaviour pattern. Also (Kelly 1971) called for a standard profile in recognition of the complex behavioural system.

If the Action-Reaction analogy is continued then it can be anticipated that the teaching/Learning - Assessment/Examining/ Evaluation relationships will involve a time lag:
Consequently an instantaneous relationship between the total curriculum and an equally holistic view of assessment etc., may observe a relationship which is seen to be simple in the long term.

6.1.8 It is against this complex shifting system that the contribution of Electronics within the syllabus needs to be evaluated. The subject must contribute to the present view of the curriculum if it is to be acceptable and also the subject must allow assessment by techniques currently acceptable.

6.2 WHY ELECTRONICS SHOULD BE IN THE CURRICULUM.

Reasons in favour of electronics appearing in the curriculum are given by M.E.P. in their information files, see appendix.

6.2.1 The first reason has a long-term sociological significance as by creating a public awareness of electronics, the future relationship between the public and scientists may be shaped. Electronics offers an opportunity to teach concepts and skills using up-to-date materials in such a way that the general public gains an awareness of technological-social-political issues; both in terms of present-orientated knowledge e.g. microprocessors; future-orientated knowledge e.g. rate of change and new to acquire new skills: (Meighan and Brown 1980, 142) The experiences given to students will form a basis for a more informed decision forming process in later life. (Maskill and Wallis 1982) suggested that "If effective problem-solving activities are to be taught in schools , the most sensible place to begin would seem to be in problem-solving activities familiar to the pupils, rather than in the science lesson". However, many uses of electronics vis: door bells, automatic door opening, simple alarms, etc. are a part of everyday life and accordingly electronics offers a usable basis for introducing problem-solving. The link between practical work, project work and everyday applications of electronics enables the curriculum to include experience from outside school consistent with the views expressed in Schools Council Working Paper 70, and in a current discussion paper by D.E.S. on Homework.

It would seem possible that such links may be developed thus adding to public awareness and continuing education outside school. (Whitfield 1979) referred to the importance of the family as an educational resource, perhaps projects in electronics are more likely to draw on family resources insofar as was noted above, electronics have several everyday applications.

Arising from the tentative link to the public through schools there is the further point that if there is interest within the family, then as electronics will allow humanitarian and social aspects to be developed at an early stage, it may be possible to encourage girls to participate in the subject. This would be significant in enabling "all citizens" to contribute usefully to a society which constantly needs to adjust to socialogical and political consequences of change. (C.Dunn 1984) reported that as a practising teacher, in her experience girls like the systems approach and working with models. A further aspect of the family link is that the link touches on the concept of de-schooling: (Illich) which if devloped would require that the "... tools and components..." were "... within reach of all...". This significance should be considered in future syllabus developments.

6.2.2. The second M.E.P. reason is very broad, perhaps a key-word is motivation. In discussing 'Readability' (Johnson 1979) wrote " A young electronics enthusiast may read and persevere with a complex electronics magazine but quickly abandon the simplest history text-book. This internal motivation is very powerful, but not easily modified by a teacher ". Such motivation is generally noted by electronics teachers and it provides a potential stimulus to both boys and girls to continue their study to a more advanced level. It is this motivation which enables students to readily accept ideas foreign to an older generation with confidence, it is this motivation which is observed to encourage adults in their F.E. studies. However it should be stressed at this point that there is no immediate correlation between attitude and achievement; (Fraser 1982) observed a poor correlation and suggested that what was important was that which enabled the student to grasp the problem.

The practical work in electronics can enhance this motivation and contribute to student enjoyment and satisfaction as they gain understanding of the relationship between practice and theory: (Davies and Penton 1976); note that in the context of this study, practice is placed before theory as suggested by (Woolnough 1983). The enjoyment is facilitated by the use of modern equipment and components, which allow work to be done quickly with versatility and reliability. As (Palacio 1984) noted reproduceable observations are a " necessary requirement of science ", also " There is a 'bonus' for pupils if they are encouraged to use their observations to, for example, identify patterns and/or make predictions as opposed to simply make observations obtained from precision practical skills. It is through using observations in this way that conceptual development can take place which in turn may lead to a general improvement of the observations the pupils make ". This view is consistent with (Bruner 1966) who pointed out that the process of discovery can lead to an appreciation and understanding of the nature and art of inquiry.

6.2.3. (Smith 1978) observed that " most school science courses give children little training in the information-processing aspects of scientific works...". Electronics readily provides such 'training', as experimental data can be compared with published values and the students are increasingly encouraged to use published information from a wide variety of sources as the more formal practical work leads into project work. Students can be introduced to the use of catalogues etc. to gain a basic appreciation of costs and then to cost out their own project. Project work is perhaps the strength of electronics as it extends the practical and thoery work allowing the development of skills in specification, planning and problem solving in context. The paper work is not tied by subject boundaries as in many other subjects and the project work offers such a wide range of 'spontaneous' problem that electronics is not open to critisism such as that given by A.S.E. 1979 "...many of the Nuffield courses have spawned contrivances to produce the right answer nearly every time ". Other than offering students the opportunity to 'see if it will work as intended, the project allows the student to explore and find out' what else it will do, quite often not only inside the laboratory, but also outside of the school.

That skills are developed as a realistic context is important. (Woolnough 1983, 61) criticised the 'artificial game' of experiments as leading to the destruction of pupil enthusiasm. (Smith 1978, 147) observed 'it is highly likely that some sort of direct participation in realistic scientific work might give a more meaningful impression of 'scientific method' than much of the parlour magic which still passes currency as experiment..." ; further the choice of realistic practicals may encourage children to follow science if "...they can percieve scientific disciplines as appropriate activities for normal adults ". The inclusion of data references other than those from conventional text-books can relate the work of students to a more adult level and adds purpose to the information-processing referred to above.

Thus the student motivation can be increased by relating their individual work to a range of disciplines, interests and situations. Conventional laboratory work affords skills in the interpretation of constructions both written and verbal. The project work builds on motivation and considerably extends those basic skills acquired in the formal practical work.

6.2.4 The project work is nearer to an individual learning situation than most situations and it can lead to a better teacher-student relationship: (Green 1982). The teacher can show an encouraging 'warmth' by using the pupils ideas and giving an encouiraging feedback. This situation can encourage and allow the student more creative thought and self-realisation, which can be developed at the students own pace. Findings from the A.P.U. certainly suggest that given the opportunity and encouragement the students can manipulate circuits and at their own pace more students may be successful. Many students find that at their own pace they can 'learn how to learn', perhaps they do not phrase it as Bruner did, but it is not unusual during project work for a student to comment on their emerging 'self appreciation'. Such observations are consistent with the opinion of writers such as (Taylor 1968, 82) who suggested that subjects other than those normally on the time-table may be more appropriate to the student and to the range and scope of learning required. The project does allow a concentration to be given to the student by the teacher and the electronics core allows the students to integrate their own interests, hobbies, subject strengths. Certainly the improvement in student academic progress often rated during project work tends to be a broadening educational experience rather than a narrow specialisation.

6.2.5 (Armstead 1979) in his case in support of project work noted that project work allowed assessment of factors on student development otherwise ignored. One unexpected bonus of project work is the spirit of co-operation which can develop within a class: if students are made aware of each other's activity they will readily interchange relevant references and make due allowance for the sharing of equipment as work proceeds. It is not usual for such a life skill to appear in team and group activities but not at such a personal level as this in a science subject. Indeed in terms of compiling a student profile this characteristic of co-operation may be usefully included:
(See A.S.E. discussion of the Aim 2 of 'A Basis for Choice', 1982).

6.2.6 (Whitfield 1979, 423) identified 'teacher traits' which he described as critical in the development of the teacher-student relationship, one being 'demand', noted also by (Lord 1984, 36). The use of Notes for Guidance and Marking Schemes issued by some Examination Boards allows students to be introduced to practical work in such a way that they try to achieve a high level of planning, presentation etc. (See 4.3.5.8.) As students progress through the experience of forming verbal decisions as the work proceeds to the formation of written decisions in their report, they can be gradually introduced to related experiences of conceptual clarity. The use of B.S. symbols, necessary related work, use of language etc., are introduced in a way that is relevant to both the project and the written examination. Concepts and detail introduced in this way can enable the students to have better recall over a wide range of topics.

6.2.7 Armstead observed three weaknesses associated with project work:

i) inadequate laboratory facilities.

ii) difficult for students to formulate projects in Chemistry and Phsyics.

iii) difficult to define and access projects objectively.

The first of these weaknesses continues to be a major problem; (Green 1982) also referred to the need for resources including books if students were to work individually. Further comment is made in Section 8.

On the second point by contrast with Chemistry and Physics, Electronics allows a very wide range of projects to be developed often of intriguing practical applications, often relevant to everyday applications rather than abstract applications. It is this wide range which prevents an emphasis on standard routines "which are unrelated to pupils' everyday experiences" too often found in examination orientated subjects: (Scarth 1983).

Armstead himself provided a basis for assessment, which, (See Appendix), was similar in general form to that adopted by several Examination Boards. In general the way in which such assessments are applied allows the student to gain credit for work that was spoilt by jumping to conclusions, so that an error at a critical stage does not detract from those skills and concepts shown.

6.2.8 Many involved with project work may suggest that this activity masks a further weakness: the role the teacher is expected to play lies outside their experience in many cases. Students need to be introduced to the scope and form of projects in a professional manner by the teacher; in Ausubels terms the teacher is an 'organiser'. (Ausubel 1978) considered that learning was only meaningful if it was related to relevant concepts and ideas acquired previously. The importance Ausubel attached to the related work was shown by his use of the term 'anchor' as alternative to 'subsumer' to describe it. A similar requirement was given by (Bruner 1966). Writers such as (Kuble 1983) and (Summers 1983) considered that the view of Ausubel was consistent with Piagets concept of stages where each stage was not simply a biological stage rather an interweaving of several concepts.

The importance of the underlying concepts was supported by the work of (Kempa and Nicholls 1983) who showed that although both 'good' and 'bad' students have a similar awareness and appreciation of strategies it is those students who have the appropriate cognitive structure who were able to implement the strategies. Where the project would involve a student to a concept or skill too early the teacher may need to leave an idea open-ended to avoid a conflict between expectation and reality. It is insufficient for the teacher to allow the student to merely correct components and/or systems together and record observations, such a procedure is not making effective use of Electronics. The students need to appreciate the whole situation so that "meaningful observation can take place": (Woolnough 1983, 61). (Working Paper 70 p.22) made the point that knowledge without skill has a long sad history, but it is not enough just to introduce the two without due consideration.

(Wellington 1981) pointed out that there is danger in students learning within their own context, a view also expressed by (Summers 1982); the way in which students use language may not be appropriate to project work and they may require assistance from the teacher in the interpretation and use of words: (Osbourne et al 1983). The student may need to be directed without being given specific assistance. Also the student may need to be shown that their observations in their context are not valid as other considerations were overlooked.

When several students are proceeding simultaneously the teacher will be faced with many novel and conflicting situations, which if not dealt with efficiently, will detract from the value of the project within the curriculum. On one hand the teacher must allow students imagination and on the other hand be conscious of Wellington's concern that the students may be deceived into thinking they are at the frontier of Scientific research.
Further aspects of the teachers problem are discussed in Section 8.

6.2.9 The range of activities described so far in this Section are capable of embracing both a wide range of Hirst's forum of knowledge and many sociological, political and economic features. Not all students will be at the same stage of development awareness and they will each benefit individually from the 'total intended curriculum'. As in other subjects, the teacher must guide the students as noted earlier and the teacher must be aware of the danger of trying to satisfy too many undistinguished aims: (Summers 1982). (Mee 1982) showed that alternative arguments may be used to justify the inclusion of Electronics into the curriculum showing in his thesis that Electronics meets the criteria suggested by (Raths 1971).

6.2.10 The remaining M.E.P. reason why Electronics should appear in the curriculum raises two separate issues:

i) what is the manufacturing and economic future of the

U.K.?, a feature outside the scope of this thesis!

ii) can the 'special' pupils be identified? Reference was made to the complexity of education and the tentaive changes being made. (Hilton 1984) proposed that the profiling of skills may be usefully applied: this technique "can give credit for the variety of skills included in Science activities", and can be based on the students own activities. The checklist given by Hilton has a similar form to the A.E.B. 'O' level Electronics project marking scheme but the profiling differs as it is on-going summative. Also Hilton includes an oral assessment as suggested by Armstead, (Schools Examination 1978, 75) etc., and similar to the F.E.U. style of profiling.

However, whether or not knowledge and skills can be distinguished is contentious: (Thompson 1984). What is equally contentious is whether those with particular abilities have a sufficiently broad range of abilities to be able to continue their studies in higher education to gain qualifications as Scientists and Technicians, and whether industry and commerce will otherwise employ them. There is a danger that present broad traditional evaluation patterns will continue to be used as a basis for entry into certain courses and employment: As (Blaug 1983) observed "Screening by educational qualifications is economically efficient not because 'good' students are always 'good' workers but because educational credentialism avoids the inherent conflict of interests between workers and employers".

6.2.11 Conclusion

It would seem that the subject of Electronics could usefully

contribute to the present conception of the curriculum especially if a project is included, regarded as a learning process in its own right (Mansell 1984, 12), and supported with adequate resources. Also the range of assessment techniques used with Electronics can be broader than in many other subjects. Any contentious debate over the purpose of the curriculum and the value of assessment techniques such as 'who is the profile for?', would apply to any other subject.
Where in the curriculum Electronics should be offered will be considered in Section 7.

6.3 ELECTRONIC SYLLABUSES AT '18+'

The introduction of Electronics into the curriculum will now be considered with particular reference to B.T.E.C. and A.E.B. G.C.E. Electronics courses. The origin, context and growth of the subjects offered by these examination bodies will be traced in relation to the theories of innovation discussed in Section 4 and in relationship to the changing pattern of education discussed in Section 5.

A general view was expressed by (Galton and Eggleston 1979): "Each subject curriculum had its own philosophy embedded in a statement of aims, they had in common the intention of moving away from the traditional view of Science as taught in schools as a set of received facts and principles."

Both G.C.E., B.T.E.C. and other bodies are seen to move from a traditional stance to present new ideas and explore new ideas rather as suggested by Egglestone (6.1.6).

6.3.1 Ordinary National Certificate (O.N.C.) - Technicians Examinations Council (T.E.C.) - Business and Technicians Examinations Council (B.T.E.C.)

6.3.1.1 The O.N.C. in Sciences Scheme 1965-66 replaced the S1 - S4 Applied Sciences examinations. Students were required to study three Basic subjects and one Elective subject for a minimum of 120 hours with English and General Studies as Additional Subjects. Various criteria were specified for the award of a certificate.

The General Notes for Guidance advocated integration of subject teaching in breadth to provide a broad foundation; practical work would take one-third of the total time available at basic level and two-thirds at elective level. The syllabus used could either be that nationally established or that approved on behalf of a centre; examinations could either be externally set and marked through a Regional Council or internally set and marked with external moderation.

Teachers were given no assistance in analysis of the syllabus and only those staff on moderator panels could reasonably gain access to marking schemes to determine the relative importance of topics. Thus the teacher approach tended to be that identified by (Scarth 1980): "a tendency to emphasise standard routines and concepts which are unrelated to pupil's everyday experiences."

In addition to the introduction of the liberalising influence of

English and General Studies the syllabuses made other innovations: In physics the transistor and solid-state diode were introduced and the Elective syllabus broadly covered several areas of Applied Science.

In 1975 a revised syllabus was issued. This required that in Basic Physics the examination paper included "Section A consisting of compulsory objective type questions requiring short answers on which candidates will be advised to spend about one hour, and Section B consisting of seven traditional type questions, from which candidates will be required to answer four." Also time allocations were suggested for the teaching of Sections of the syllabus; supposedly this feature related to the emphasis of the examination questions.

The content on semi-conduction was extended at Basic level to include the transistor and the photo-conductor. The Elective syllabus was extensively revised losing much of its Applied Science character, this syllabus now included more detail on transistor amplifiers, transistor oscillators and switch, and zener. (See Appendix)

These gradual changes in content conform to the process identified by (Miles 1964, 638) "familiar processes near the present pattern were likely accepted."

As noted in 5.1.6, T.E.C. was introduced to replace Regional Boards and the T.E.C. examinations commenced 1980. The T.E.C. syllabuses were highly structured using Bloom's terminology, the assessment being based on specific objectives. Unit lengths were sixty hours and to gain a certificate a student was required to gain credits in fifteen units either by exemption or examination involving Level II and Level III units which loosely corresponded to the previous Basic and Elective levels. Centres could design both their own Units and Programmes to suit local needs rather than use the models offered by T.E.C.; writers such as (Russell and Latcham 1979) of the F.E. Staff College gave advice on the writing of Units etc.

Internal assessment was continuous with an visiting external moderator. Those students who met the admission requirements were expected to "be successful in their studies" if they studied "reasonably hard and well.", the purpose being to reduce student wastage.

(Halliday 1981) later questioned the vagueness of the T.E.C. Notes for Guidance on this point suggesting a lack of clarity as many teachers gave the interpretation that 'all students get an award!'

General aims of the T.E.C. programme were given also specific aims for Units, these were intended to "reflect the analysis of the function and future development of the technician." The formulation of learning objectives in their structured form was designed to:

i) facilitate the assessment.
ii) minimise ambiguities and difficulties of interpretation.
iii) assist in selecting teaching/learning strategies.

iv) provide a framework for the guidance of students, teachers and others.

Thus the 'hidden-curriculum' was to be avoided - if the staff and students had the opportunity to read and appreciate the regulations!

(Roberts 1976, 21) noted that (Stenhouse 1975) had considered the use of objectives as being more appropriate to training. Many would consider technician 'education' to be 'training' so the use of objectives may be acceptable. However, (Pope 1983, 29) noted the creational curriculum of T.E.C. and suggested that planning by objectives does not allow a mix of assessment styles involving illumination etc. (MacRory et al, 1977) advised that the use of objectives may not improve practise, a point touched on by (Williams and Panton 1977) who criticised staff and institutions for not getting further involved.

The introduction of a 60 hr unit allowed a wider range of units to be offered. An innovation was the introduction of a Unit in Safety and Laboratory Practise Level I. Compared with the O.N.C. syllabus additional topics were Op-Amps., Logic, F.E.T. devices otherwise the objectives given in the T.E.C. Electronics Units were generally consistent with the content of Elective Physics examination questions.

6.3.1.2 However, despite the intentions of the T.E.C. scheme in general, many criticisms were made. (Wilson 1983, 30) wrote "T.E.C. has avoided the issue of the relationship between what is taught and how it is learned, and has failed to give guidance on how its courses should be tauight." This is a criticism similar to that made by (Russell 1975) of the Schools Council and Nuffield projects. Wilson further suggested, p.31, that T.E.C. and its associated body B.E.C. attached even less importance to the effects of classroom changes due to innovation than those other bodies had, making no attempt to help the teacher by the production of teaching aids. Similar criticism was made by (MacRory et al, 1977, 5-6) and (Roberts 1976, 21-22). (Halliday 1981) observed that in the assessment the teacher was being required to judge both the measuring instrument ie. the examination style etc., and the student performance, he doubted the viability of the assessment procedures to relate to the objectives considered to be being assessed. Halliday asked that:

i) Aims were selected so that direction was given to the curriculum.

ii) More guidance was given on how to promote the aims.

Further criticism of T.E.C. policy was made by (F.E.V. 1981) who identified three main issues:

i) Isolation of curriculum issues from those of organisation and resources.

ii) methods of dissemination.

iii) need to trial test and evaluate.

Similar points were made by (Roberts 1976) and (MacRory et al, 1977).

6.3.1.3 The F.E.V. report considered the six modes of interaction identified by Eraut:

i) Printed materials: syllabuses, circulars, guidelines, books, exam papers and reports, non-personal letters, journals etc.

ii) Information/advice: (via correspondance or telephone) from the secretary, adviser, moderator, examiner, representative, officer or any other members of staff in an organisation.

iii) Conferences or gathering where speakers and audience are clearly defined and where matters discussed are general ones as opposed to;

iv) Courses where those who attend are more likely to make a contribution or to find at least part of the work more tailored to individual interests and needs.

v) Face to face contacts: discussions, interviews etc. with staff such as those mentioned in ii) above.

vi) Working Parties or Workshops: discussions groups, simulation exercise or meetings to plan, draft etc.

In general these models were not entirely successful either giving only bare facts in jargon or being limited by expense, holidays, L.E.A. policy etc. There was general approval of the contact with the moderator.

6.3.1.4 T.E.C. themselves did send officers to other disseminating agencies eg. Coombe Lodge, Colleges of Technical Education and stressed the need for an intermediate body. However, major weaknesses were apparent:

i) Guidance Notes were issued with "motivated practising teacher in mind."

ii) With respect to (Gronlund, N.E. 1970), (Bloom et al, 1956), (Mayer 1962) it was thought resourceful of staff "... able to pick things up and make something of them."

(Wilson 1983, 33) suggested T.E.C./B.E.C. relied on power-coercion. The F.E.V. survey indicates staff resented being told what to do rather than being "positively involved in decisions."

The report identified "the chronic problem of updating subject matter and skills, often linked with the need to acquire new skills and knowledge in planning, designing, implementing and evaluating curricular along the lines required by the validatory bodies." A 1985 H.M.I. report made similar comments: (Lodge 1985).

6.3.1.5 After T.E.C. and B.E.C. merged in October 1983 to form B.T.E.C. a set of tactics were identified:

1. Consideration of the professional and pedagogic background of the message receiver.
2. Designing different messages for different groupings of staff.
3. Providing illustrative examples of new concepts and practises.
4. Identifying sources of complementary explanation.
5. Publicising examples of good practise.
6. Assuming the availability of other agencies who could aid

message interpretation and, where possible, working with them.

7. Providing a 'message querying' service for message receivers.

8. Providing a glossary of terms for each new curriculum venture - especially where new concepts are being introduced using terms which already have an established meaning.

Unfortunately resources would not allow the implementation of these policies even though they would have made the total exercise more cost effective, (House 1974, 9) wrote of innovative failures "Financial and interpersonal costs are so high that sponsors usually resort to impersonal communication modes like the dissemination of materials." Certainly the T.E.C. programme seems to support this view. (Stenhouse 1975) stated "Education is not in practise very sophisticated or efficient." The theory may be sophisticated but the practise is not!

Nevertheless whatever criticism could be made of efficiency etc., in terms of electronics, as (Dean 1981, 12) commented B.E.C. and T.E.C. gave an impetus "just when it was needed." A study of the developments of T.E.C. Electronic units from 1976 to 1981 show how syllabus content changed radically.

6.3.1.6 Since the standard units appeared in 1976 several changes in content and form have taken place. At Monkwearmouth C.F.E. the T.E.C. Science programme was introduced and Electronics and Material Science units were included. The Level II Electronics was derived from Electronics II U76/029 in the Engineering programme by omitting Thermionics and moving towards solid state devices. The Level III Electronics was the standard unit U76/009, (See Appendix). The decisions were taken so that the units offered could be related to the resources either already available or being developed for both 'A' level Physics and 'A' level Electronics Endorsement. The decision was in line with the H.N.C. Physics Technician Programme March 1979, T.E.C. code 09-016-T, published later.

In 1981 standard units U81/848 Electronics System II and U81/849 Electronics System III were included in the Science Programme. At Level II several changes were made:

i) All work on semi-conductor physics, p-u junctions, use of diodes in rectification was omitted.

ii) The treatment of transistor characteristics and small signal amplifier was considerably simplified.

iii) Waveform generator was omitted.

iv) Transducers and Display were added.

The changes of Level III were:

v) Amplifiers, feedback and R-C networks were omitted.

vi) Bistables, Registers, RAM, ROM, etc., were added.

vii) More details on the Op.Amp. were added.

viii) An Assignment was added.

The effects of these changes were to move from thermionic and/or transistor devices to integrated circuit devices and towards interfacing. At Level II the number of specific objectives changed from 97 to 37, at Level III the number of specific objectives changed from 59 to 51. The policy of reduction in the number of specific objectives is currently being considered by a working party; the present policy seems to require more cross referencing of specific objectives to other activities as a "knowledge-developer": (6.1.6). In this context the inclusion of an assignment and T.E.C. encouragement to do so at Validation gives the opportunity of cross-referencing. Also the assignment offers the opportunity of extending the assessment outside of the Cognitive domain to the Affective domain in terms of "enthusiasm, diligence, ability to work successfully with other people." T.E.C. Assignments and Assessment 83/3 E.C. March 1983. These features are discussed in 6.2.5.

6.3.1.7 The Electronics and Telecommunications Programme A2 includes Electronics II U81/743 which is similar to Unit U76/009, and Electrical and Electronic Principles II U81/747. The latter is 1½ units and differs considerably from U76.029 giving a much broader basis in 'physics' concepts. The A2 programme by contrast with the Science programme includes three half units on Digital techniques so that in either programme a similar course content will be followed. An added feature of the A2 programme is Microelectronics emphasising the shift towards integrated circuits and interfacing to microprocessors.

6.3.1.8 A Technicians Studies course designed by B.T.E.C. was successfully piloted within Y.O.P. provision in nearly fifty centres during 1982 and 1983. Subsequently the scheme revised to meet Y.T.S. requirements and the scheme is now being offered within T.V.E.I. Schemes, it could also be used on C.P.V.E. Schemes. Further reference is made in Section 7 to both the

Technicians course and to the Microelectronics Programme designed by (Neale and Wilson 1984) and released by F.E.U. in response to the Alvey Committee recommendations.

Both of these recent B.T.E.C. initiatives show clear signs of central directions in response to D.T.I., and D.E.S. policies.

At present B.T.E.C. proposals include a qualification for 17 - 18 year olds in full time education not as an alternative to C.P.V.E. at 17+, the main areas of study do not as yet include Science.

6.3.2 A.E.B. 'A' Level Electronics Systems, 658.

The A.E.B. Electronics Systems 'A' Level was developed under the guidance of Professor G.B.B. Chaplin at Essex University: (Chaplin 1976). Basically the course included consideration of human perception, computers, and feedback and control systems, as well as circuit design. The emphasis is on a broad field of systems eg. Biology, Ecology, Sociology as well as Engineering. This course (was a Linear-Expert Model of curriculum development): (MacDonald 1975) affording an example of a re-orientation as compared with the Electronics Endorsement which was a variation: (4.1.2)

6.3.2.1 The Research and Development phases were based in the Department of Electrical Engineering, Essex University and the initial scheme was evaluated at the Colchester Royal Grammar School being followed by a three year pilot scheme in nine centres including F.E. The use of the local pilot centre was consistent with the strategy suggested by (Williams 1966),(4.2.3), and is reflected in the present strength of the course in Essex.

(Bevis 1978), who subsequently became Director of the Scheme, noted that the feedback obtained led to a course which was "... well balanced in terms of intellectual scope, syllabus breadth and timing. Mathematics was kept at a minimum so as not to obscure simple and logical concepts; the content could be covered" (in contrast with many 'A' levels) "in two years allowing depth in relation to importance."

In the 'Pilot 'A' Level Syllabus' the nature of the syllabus was described and significantly the first sentence includes "... aims to provide a preparation for modern living." Such an aim and the teaching of the principles and concepts of systems using electronics as a central co-ordinating theme or 'hub' continues to provide a unifying stimulating course. Technology was not allowed to dominate the course so that the course could not be outdated as technology advanced.

During the pilot scheme minor changes occurred in the syllabus:

i) Originally the three main sections were given as: Television and Audio fundamentals, Computers, Feedback and control, Ciruit design. Subsequently the content was presented as Communication System,. Computer Systems and Feedback System, with a section on Basic Electronics which could either be taught separately or integrated into the three main sections. In the final syllabus 'Computer System' was renamed 'Processing System', 'Basic Electronics' was described as 'System Components' and an 'Introduction General System' was added. In these modifications the systems identity of the course was gradually being made much more explicit.

ii) The Master-Slave technique was deleted and specifically replaced by the Data-type bi-stable. The F.E.T. was deleted, no specific emphasis placed in the Telephone, Communication System had the Superhet receiver and the moving coil principle and devices added, the content on the Op.Amp was considerably extended, and Fortran language was replaced by Basic. These changes reflect both the evaluation feedback and availability of components etc.

iii) The experiments were intended to leave scope for initiative, variable depth and to be open-ended so that the experiments were readily adaptable to future change in sixth form examinations. Originally laboratory work was assessed on a range of fourteen experiments involving: "the students' grasp of principles rather than measurement techniques or style of report." The assessment was changed to involve two projects/investigations of about 10 hours and one project/investigation of about 20 hours. Recently this was changed to six experiments of at least 4 hours duration in the laboratory and one project of 10 hours laboratory work, and the assessment scheme now allocated approximately 25% marks to evaluation of performance (measurement) and style of report.

The results of the pilot scheme persuaded the Schools Council that the course was not too vocational and the course was released in 1976.

During the Research and Development phases the project was supported by the National Electronics Council: (Noaks 1976), who also supported the Dissemination phase.

Teacher courses eg. course N106 Electronics Systems (Sixth form) 6th-9th July 1970 which commenced during the pilot stage gave teachers and advisers an opportunity of early involvement (4.3.5.3). Also in the pilot stage it was made known that teaching materials and laboratory equipment were developed and available from Essex University who considered that "The cost of equipping an electronics laboratory is substantially less than that for either Physics or Chemistry." (Bevis 1978) repeated the latter point; in his capacity as Director, Bevis continued to support the course by making available notes on commercial suppliers of equipment, recommended books, and Feedback published a series of course booklets and supported a Newsletter prepared by teachers. (Grace 1981) gave a summary of suitable laboratory equipment.

Thus the introduction followed a 'top-down', centre-periphery, R D and D model. The resulting syllabus identified a main cohesive theme giving explanatory notes on syllabus topics, generally providing a syllabus form which reflected teacher pressure as evinced by articles in School Science Review etc., for more guidance and less 'hidden curriculum.' These various features were consistent with those suggested by (MacDonald and Walker

1976) (4.3.5.8) and help to explain the survival of the course.

6.3.2.2 The slow growth of Electronic System may be attributed to several features which include:

i) A re-orientation innovation was considered to require technical support, and resources were important, (4.1.2). Similarly the centre-periphery requires a sufficient level of resources (4.2.9). The resources available to the Electronic Systems project did not allow the appointment of field officers (4.3.3.1) and the lack of contact inhibited the S-1 mechanism. Also the lack of resources did not allow the initial planning to be on a sufficiently large scale (4.2.8.1). In general there was not correction for the negative influences in Schools (4.3.5.9) and little support from L.E.A.s.

ii) Although it was claimed that the Electronic Systems was relatively cheap to establish, the physics resources already existed and it was even cheaper to extend those facilities to cope with 'variation' innovations such as including Electronics in Physics. The Schools Council, A.S.E. supported Nuffield 'A' level Physics project commenced September 1967 and introduced trials in September 1968 involving 500 students in 24 centres. A revised syllabus in the following year had trials involving approx. 1500 students in 62 centres. The materials which became available 1970-71 included Aims, suggestions for teaching sequences etc.

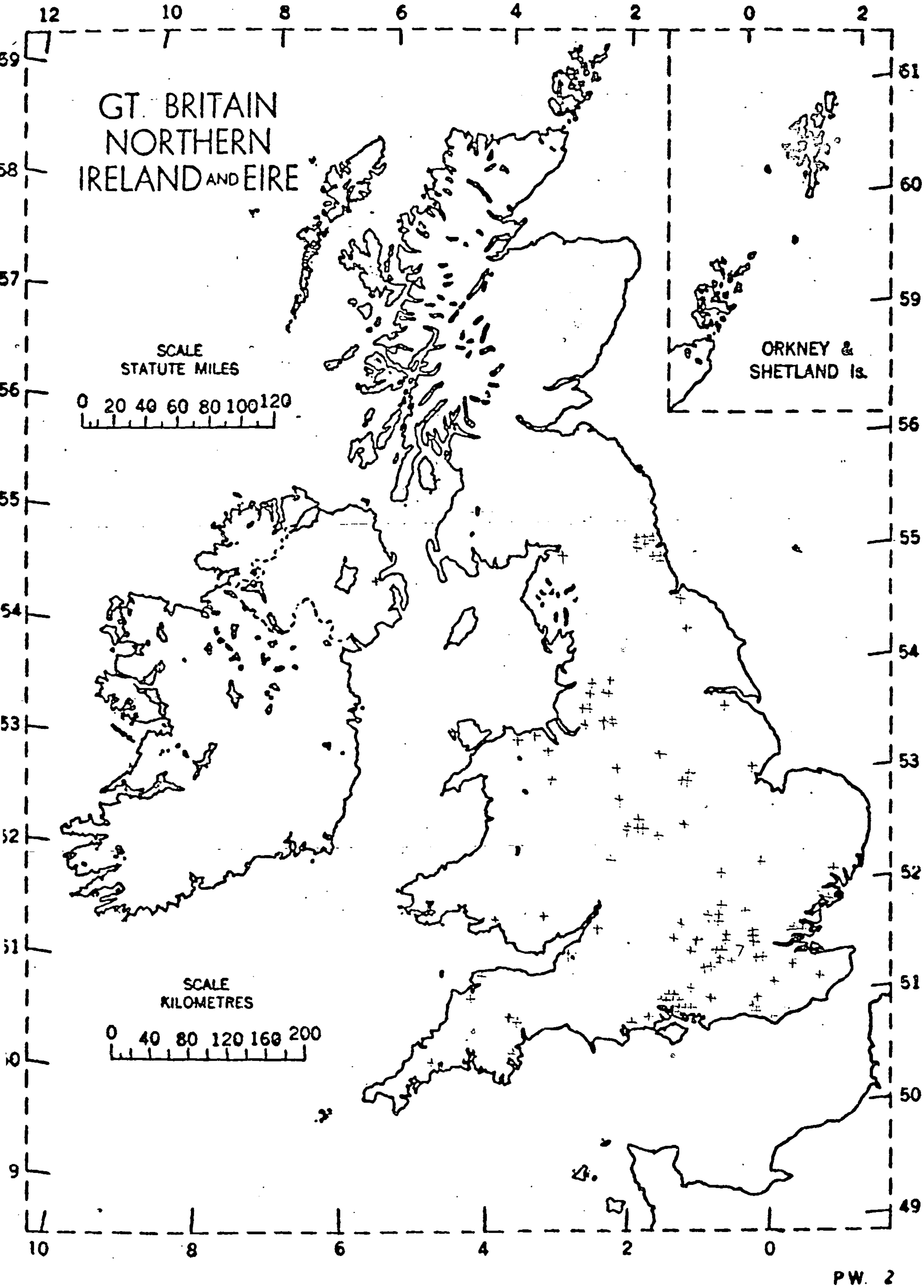
The Nuffield Syllabus included a section on Electronics reported by (Nicodemus 1975) to be extremely popular. (Tebbut 1981) wrote "It was seen to be relevant, well organised, capable of catering for pupils of all abilities, generating confidence and enjoyment."

Thus (Summers 1983) wrote that the Nuffield 'A' level Physics "pioneered an approach to electronics teaching using conceptual building blocks:" An alternative retrospective view is that the resources available to the Nuffield made it more attractive to L.E.A.s and the integration of electronics placed no further pressure on the time-table; also that the Nuffield Electronics component delayed links to technology and the growth of electronics. Criticism was also made of the Nuffield 'blocks' insofar as they were considered by some as not being appropriate: being able to switch like traffic lights but not in the same order. Details of the original syllabus and the new syllabus are given in 6.6.1.

6.3.2.3 Other contemporary relatively highly funded projects such as Project Technology have substantially died away leaving residual traces in the N.S.C.T. and C.D.T. itself, only seen as an idea by Project Technology. It is interesting therefore to consider why Electronic Systems survived and why the innovation did not peel off (4.3.1.5).

The Electronic Systems offered an appeal to specialist staff who were opportunist (4.3.1.2), and invariably as resources never allowed a band wagon effect, such staff received encouragement from student enthusiasm (4.3.2.2). The scatter on the map of

Map 6.9



Location of Centres for the AEB 'A' Level Electronic Systems 659.

centres, and conversations reveal little ripple effect rather than an Urban spread as suggested by (House 1974) (4.2.10.2), and lasting S-1 effects from this pilot scheme.

F.E. always had a strong level of involvement perhaps as in many colleges the equipment required to achieve a threshold (4.3.1.1) was available in consequence of O.N.C. and later T.E.C. courses. As (Marsh 1964) noted (4.3.5.2) teachers themselves will push an idea along, they are not passive. Given the opportunity teachers started courses trading off viability of class numbers, in this sense the growth of F.E. gave very healthy Physics groups from which a smaller Electronic Systems group could be formed.

The statistics show the average number of entrants to be in 1983: 6.84 students; in 1984: 6.66 students. The change in centres from year to year (volatility) is perhaps a consequence of small numbers, staff turnover etc., and is indicated by the fluctuations of centres offering candidates in 1983: 99 centres; compared with 1982, 18 ceased and 26 started. In 1984: 120 centres; compared with 1983, 25 ceased and 28 started.

In 1982-84 about 40% of the centres were in F.E., in 1984 44.8% of the candidates were in F.E., the growth in F.E. also reflects that they do not have an assured flow of clients and they need to attract students, (4.3) using an entrepreneur tradition (Morgan and Turner 1979, 51).

Insofar as Headmasters and their equivalents in F.E. did not always actively support such initiatives, it is significant that by not refusing permission they allowed courses to continue.

However, it is also significant that the various strategies (4.0), suggest a Head to teacher direction and little attention was given to the teacher to Head strategies employed in practise.

The Electronic System growth although slow was continuous (Graph 6.1, Table 6.2), and it provided a stimulus for further development, See A.E.B. 'O' level, both by introducing ideas into the 16-18 education sector and by setting a target of educational standard and content.

6.3.2.4 In 1984 a draft of a proposed revised syllabus was released for first examination in 1987 and comment invited. This draft was supported by Notes for Guidance, Aims and Objectives, also an Examination paper with its Marking Scheme. The strength of the feedback obtained by the Board in preparing this syllabus (Sect. 6.3.8) was reflected in the fact that it was finally issued without significant change.

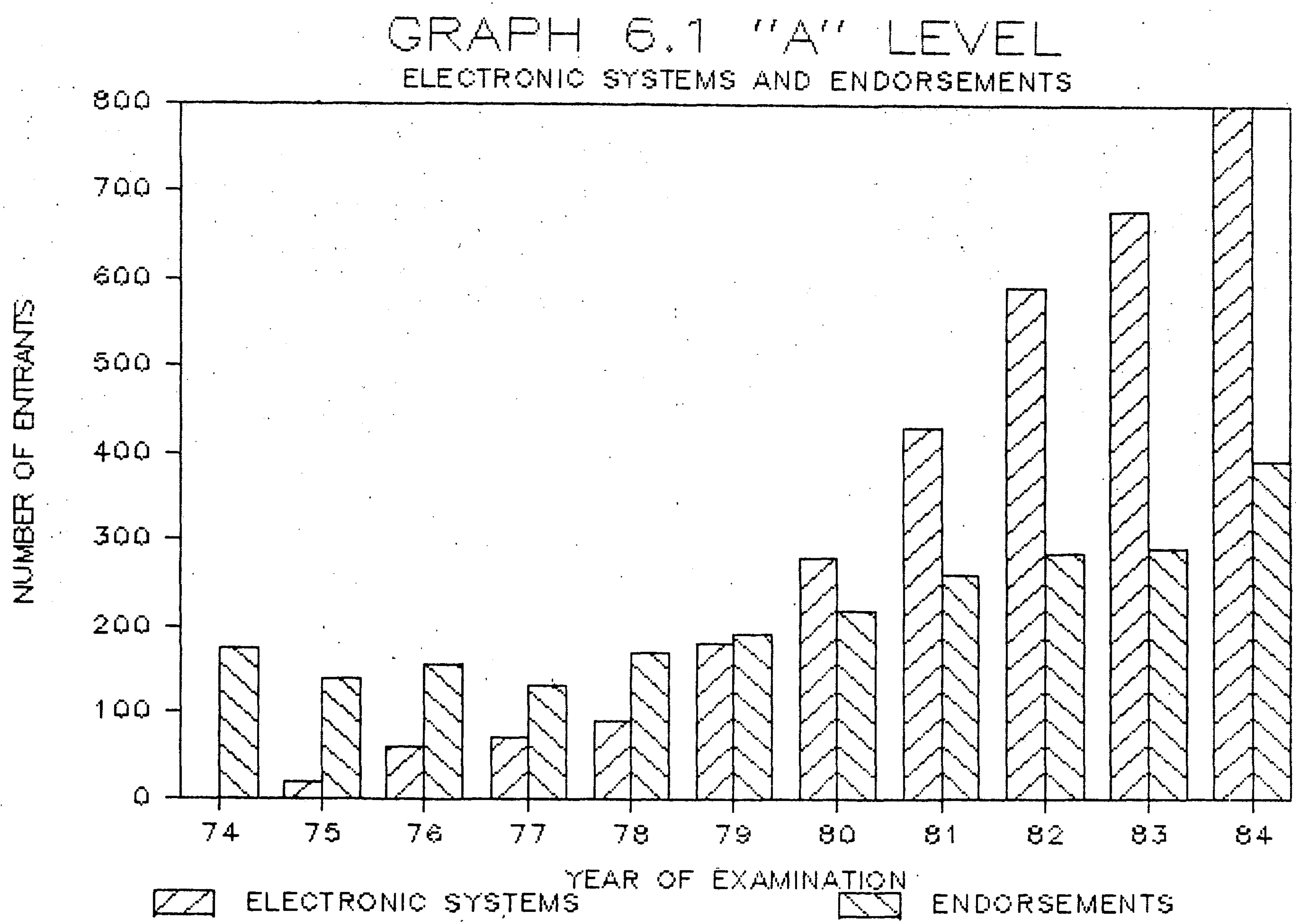
The list of Assessment Objectives included Problem solving and Skills in a form which is currently acceptable; also in accordance with current thinking the concepts of Synthesis and Applications were given much greater priority than Recall.

The detail of the syllabus was considerably extended:

i) by making detail explicit, consistent with the style of previous examination questions.

ii) devices such as the 555 timer, Schmitt trigger and the JK flip flop were added.

iii) detail was added on filters and frequency response, also



GRAPH 6.1 "A" LEVEL
ELECTRONIC SYSTEMS AND ENDORSEMENTS
800
700
600
500
400
300
200
100
0
NUMBER OF ENTRANTS
74
75
76
77
78
79
80
81
82
83
84
YEAR OF EXAMINATION
ELECTRONIC SYSTEMS
ENDORSEMENTS

digital communication.

iv) Sections were added on Transducers, Microprocessors and Storage thus satisfying the criticism made by (Pike 1982, 17).

Sections omitted were Reactance and the manipulation of Boolean functions.

The syllabus thus gave more emphasis to integrated ciruits and microprocessors especially in the transmission of data and moved further away from areas of Physics and Mathematical interest.

The Notes for Guidance included detail on Bandwidth, rise time and Sampling rate which will be outside the experience of many teachers. Also, as noted in Section 6.3.12, the Notes for guidance gave detail which is often not given in text books eg. the term Regenerative Comparator (Schmitt trigger) is usually simply given as Schmitt trigger, only a few text books such as (Morris' Industrial Electronics, p.325) use the former term and Morris uses 'Regenerative Voltage Comparator.'

6.3.3. A.E.B. ELECTRONICS ENDORSEMENT 801.

The A.E.B. examinations board was sponsered in 1951 by the City and Guilds of London, the R.S.A., and the London Chamber of Commerce. The first examinations offered in 1955 included commerce, engineering and building, subjects quite unknown in the existing 8 G.C.E. examinations boards.

6.3.3.1. The A.E.B. subsequently continued such initiatives: one was the introduction of a syllabus at A level in Physics with electronics which required candidates to sit three papers set in Physics at A level with a fourth written paper in electronics of three hours duration which was designed to 'stretch' students. On the electronics paper candidates were expected to answer six questions from a choice of ten. The emphasis of the Electronics syllabus was and continues to be on physical electronics.

This option became a separate Electronics Endorsement which retained the same syllabus:

Electron emission, effect of fields.

Thermionic diode, rectification, gas filled devices.

Thermionic diode, class A amplifier, gas filled devices.

Practical amplifier, coupling of stages, matching, feedback.

L.C.R. effects, Q factor.

Zone refining, intrinsic behaviour of Ge and Si.

Doping, majority (minority) carrier, junction diode.

P.N.P. transistor,common base and common emitter.

Comparison of thermionic and solid state devices.

This content was comparable with O.N.C. Electronic Physics and was complementary to several existing 'A' level Physics syllabus.

In 1975 the syllabus was reviewed and several changes were made:

i) The written paper was of a three hour duration consisting of one compulsory question and a choice of three from six. The compulsory question comprised 12-16 short questions and was allocated 40% of the marks; the other questions were more conventional being allocated 60% . Marks were shown on the exam paper affording the students some guidance.

ii) Brief notes for guidance were given with the syllabus which it was suggested would require four hours per week teaching time.

iii) Thermionic devices with the exception of the C.R.O. were deleted and the emphasis was placed on solid state devices:

C.R.O. deflection sensitivity.

Experiments involving conductivity-temperature relationships.

Production of junction, and planar devices leading to I.C. fabrication.

Zener diode, n.p.n. and p.n.p. transistors, h characteristics, equivalent circuits.

Emitter follower, multi-vibrator.

F.E.T. unijunction devices, oscillators.

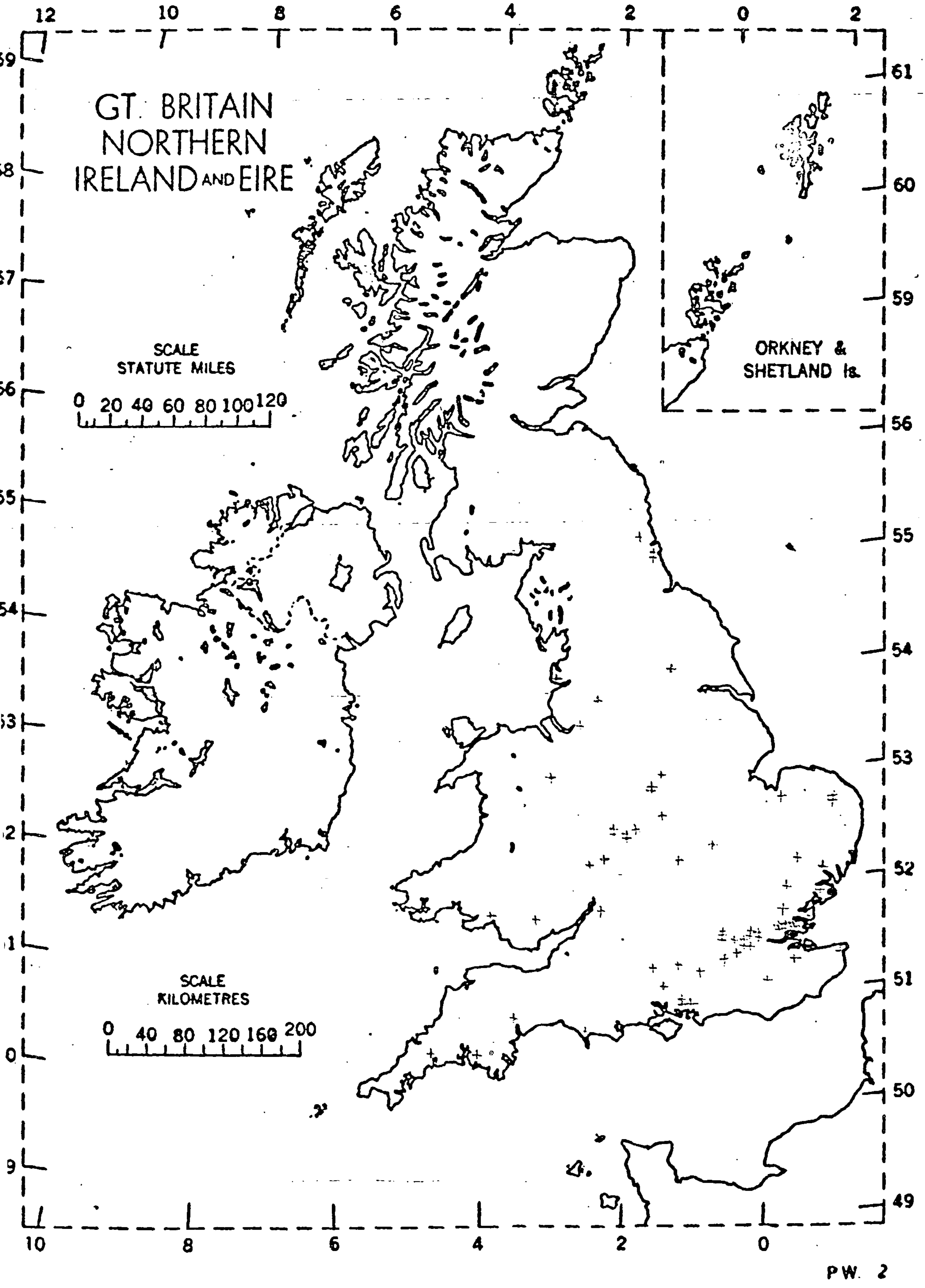
Voltage doubler, ripple.

Op.Amp. LC/RC effects for integration and differentation.

Schmitt trigger and Logic.

After the 1975 revision student numbers fluctuated and consistent growth did not restart until 1978. Whether this was because of

Map 6.8



Location of Centres for the A.E.B 'A' Level
Electronics Endorsement S10.

the move to solid state or because centres offered A O electronics instead is uncertain. Graph 6.1, Table 6.2, show the growth; more recent growth is perhaps because of the larger pool of A physics students due to the bulge, the increasing interest in electronics courses in general, and publicity. (Tebbit 1978) suggested that most interest occurred in the 'diffusion' stage but as the 'diffusion' phase for one board's proposals overlaps with that of another growth is more continuous than would be thoeretically expected.

6.3.3.2. In 1984 a draft revised syllabus was released for a proposed first examination in 1986 and comment invited. The syllabus continued to differ from the other A.E.B. Electronics syllabuses as it included the physics of semi-conductor and electronic devices. The proposed syllabus showed changes in three areas:

i) Previous sections on free electrons and electron behaviour were omitted.

ii) The unijunction relaxation oscillator, the Czochralski apparatus, Op-Amp differentiator, and detailed work on time constants were omitted.

iii) The digital content was given a clear shift in emphasis to that noted for other syllabuses. Transducers, digital/analogue conversion, display devices, sequential logic and microprocessors were added.

The draft was supported by Notes for Guidance, Aims and Objectives. The Notes for Guidance included detail on Kirchoffs

Law and Thevenins Thoerem which would allow students to identify the relationships between single transistor amplifier configurations as discussed by (Cuthbert 1976): Diagram 6.4.
Where a) and b) have the same structure as do c) and d). As Cuthbert was referring primarily to the content of an undergraduate course the rate of evolution of the syllabus can be appreciated.

The importance of Notes for Guidance becomes apparent if the detail of the content is compared with that of text books e.g. the Non-inverting Op-Amp was given in the Notes for Guidance as Diagram 6.5.
whereas authors such as Lovelace gave Diagram 6.6.

6.4 ELECTRONICS SYLLABUSES AT '16+'

6.4.1 A.E.B. 'O' LEVEL ELECTRONICS. 080.

The Institute of Electrical Engineers (I.E.E.) set up it's Schools Liason Service in 1975 the objective being 'to create a greater understanding and awareness of the electrical and engineering profession among schools'. At one of their sponsored meetings for teachers held in 1976 , it was suggested that in view of the C.S.E. interest in Electronics, an 'O' level G.C.E. syllabus should be considered. The development of such a syllabus was supported subsequently by I.E.E. and taken up by A.E.B. When the syllabus was first offered in 1982, 250 entrants were expected , but 1670 entered the examination. Graph 6.2. shows how the subject has grown to become the fourth largest science

Diagram 6.4

Transistor configurations discussed by Cuthbert

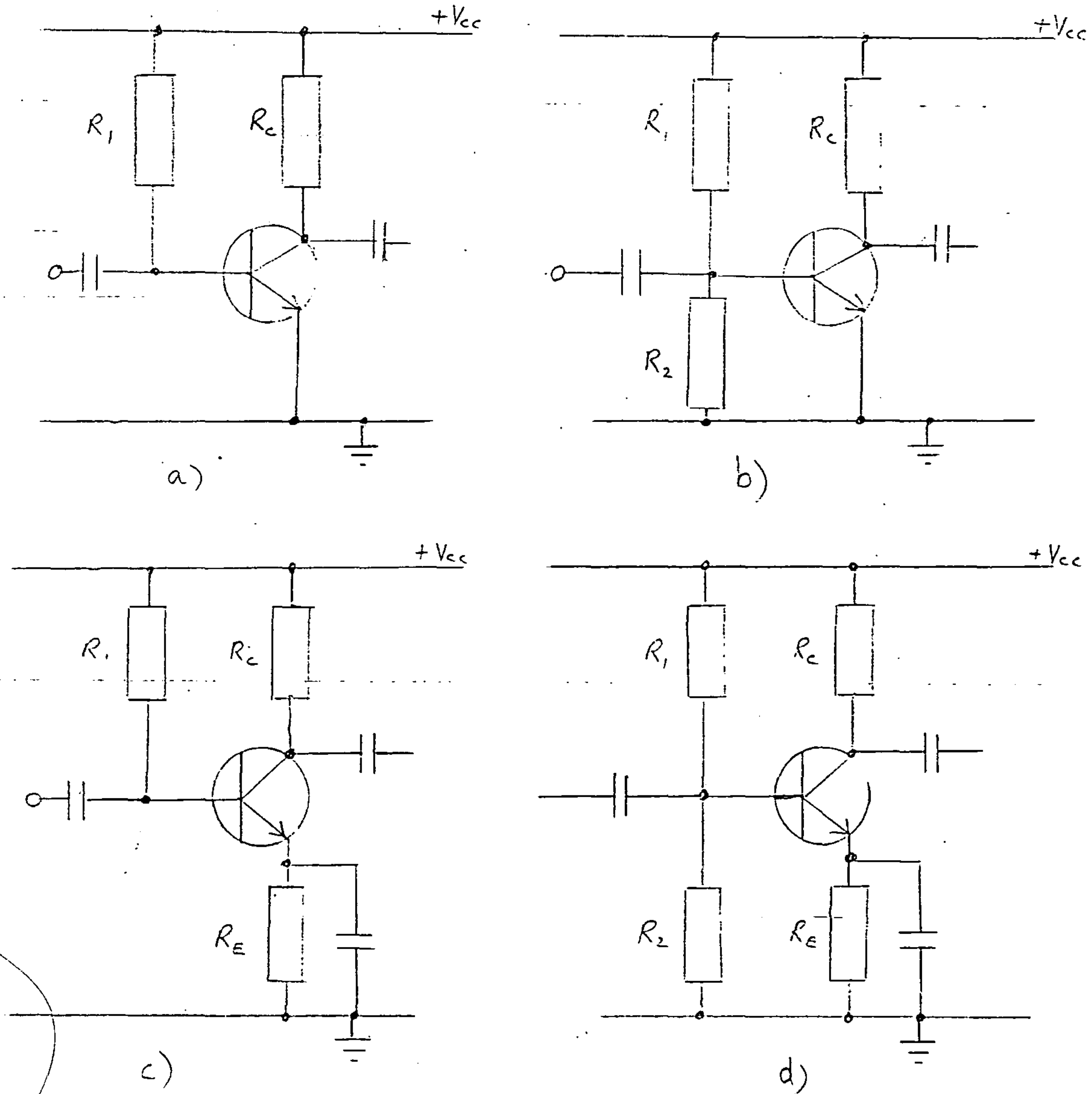


Diagram 6.5

Non-Inverting Op-Amp:

Notes for Guidance

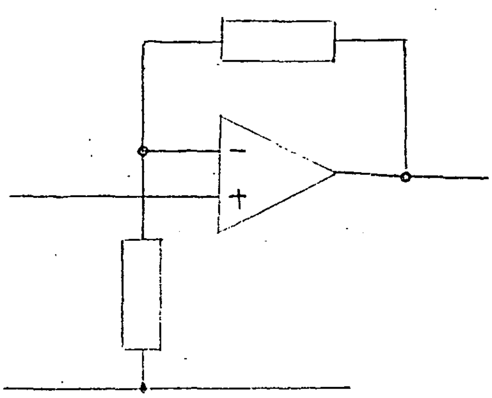
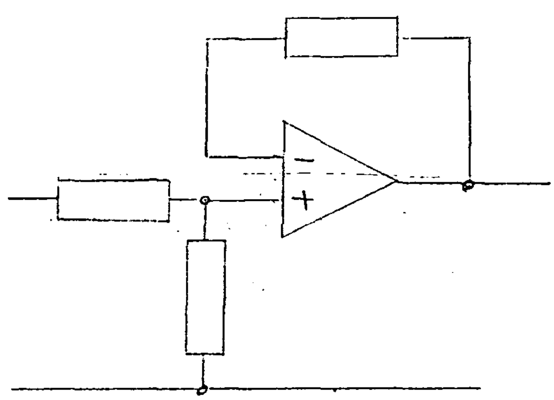


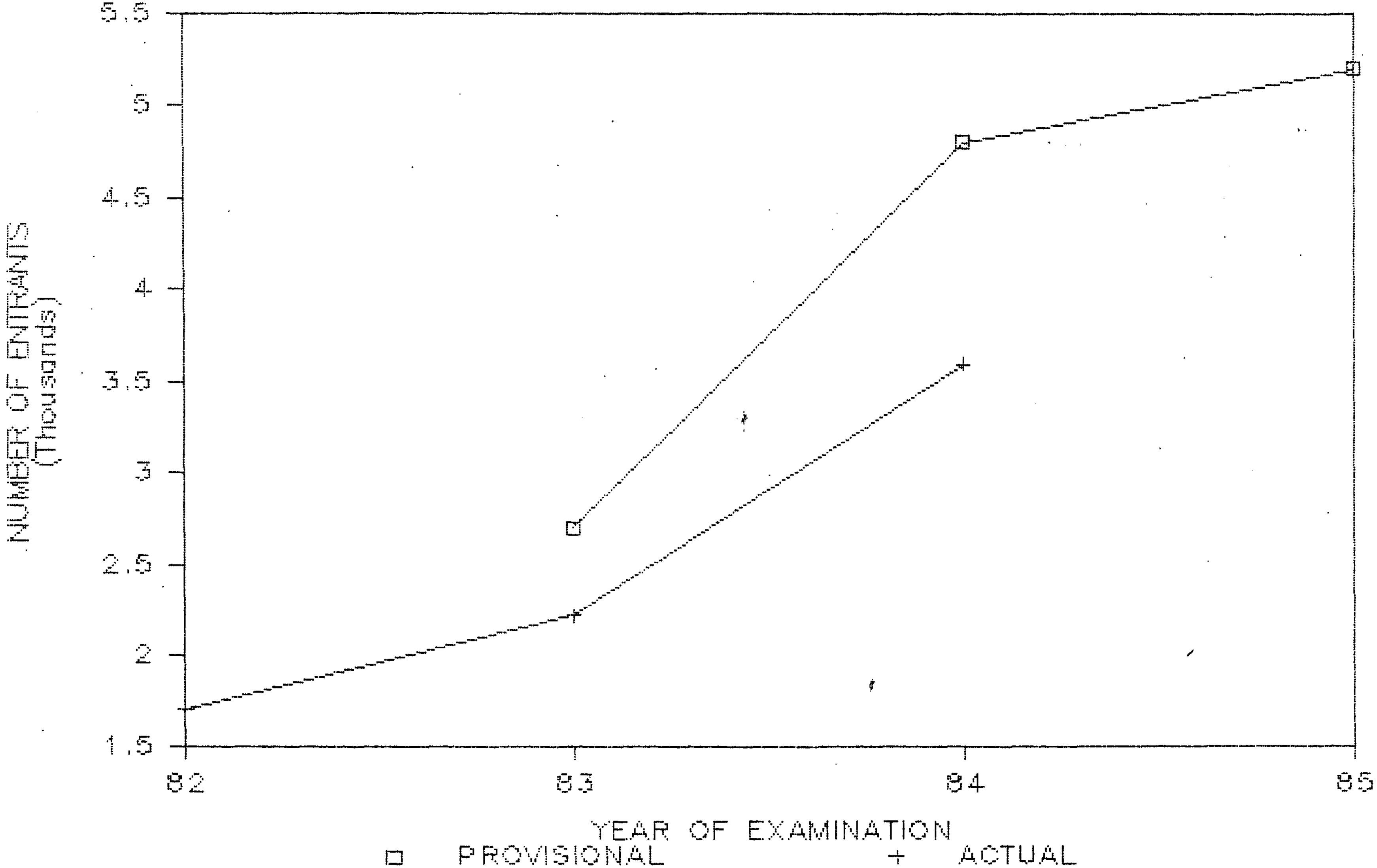
Diagram 6.6

Non-Inverting Op-Amp:

Lovelace



GRAPH 6.2 AÉB "O" LEVEL ELECTRONICS



subject in A.E.B.

The growth can be attributed to several factors:

i) The form of the syllabus and Notes for Guidance have a main cohesive theme as described for the 'A' level Electronic systems (6.3.8) and teachers were given the opportunity to comment to the A.E.B. Board as the syllabus etc., evolved.

ii) The subject was introduced at a time when the A.E.B. began to exhibit at the A.S.E. annual meeting when considerable interest was reported.

iii) The subject involves a project which is popular with students adding to the appeal of a 'modern' subject in contrast to the alternative Electricity-Electronics approach without a project used by the Cambridge Examinations Board, Table 6.3.

iv) The I.E.E. has continued to support the A.E.B. 'O' level Electronics since the idea was concieved.

v) The subject was introduced at a time of public interest when some equipment was available in consequence of C.S.E. and Ao Electronics courses and the changing content of 'A' level Physics syllabuses.

vi) A systems approach was chosen " to bring out the intellectual interest and practical skills of analysis, synthesis and problem solving." Such an approach was found to allow young pupils to quickly acquire confidence in building systems without " trouble shooting or worrying whether they have connected things together properly."

vii) In the F.E. Sector, the introduction of a G.C.E. subject gave Science Departments an opportunity of introducing a course without infringing upon the craft orientated electronics courses usually taught in an Engineering Department.

6.4.2. The I.E.E. together with the D.T.I. sponsored the development of suitable hardware by Alan Giles at Brighton Polytechnic which was subsequently manufactured by Unilab and E and L Instruments Ltd. Geddes organised and led trials of materials suitable for use with a systems approach on behalf of I.E.E. at four schools in 1982-3, and a book 'Electronics Through Systems' was published. The trial material was also made available to teachers at workshops organised by I.E.E.

(Geddes 1984) reported that the building blocks were designed to have the following properties:-

i) Ease of assembly.

ii) Few or no patch leads.

iii) Robustness.

iv) Reliability.

v) Clarity of layout.

These blocks allow students to start with a complete system and thus gain an immediate experience of the application of electronics, rather than use a conventional components approach with it's consequent long delay between the start of a course and the time when students gain an appreciation of applications. The blocks encourage students to link sub-systems together to form a "new useful system" designed to fulfil specified tasks in a very flexible manner. Finally, on the basis of the confidence acquired, students may consider the properties of individual components.

Other advantages claimed for the systems approach include:-

vi) Staff gain confidence as systems 'work'.

vii) Devices may be transient being used for only short times before a better device is introduced whereas the systems concept does not date and may be extended into other disciplines as is done in the 'A' level Electronics Systems.

viii) A flexible level of student attainment is possible, for weaker students for example Ohms Law may be given a low priority.

ix) No soldering is involved so that there is less risk of components being damaged.

x) More time is available for practical work as detailed teaching of components is not required: (Summers 1983, 201).

To familiarise teachers with this new approach, the I.E.E. Schools Liason Service with financial support from the Engineering Industry Training Board (E.I.T.B.) also ran a series of teacher workshops. The approach was further supported by the publication of 'Electronic Systems News' and by the development of materials and courses for younger age groups so that the course could be introduced earlier. The trend towards the 'black box' approach was also advocated by M.E.P. (Bevis 1978).

After the first release of course details the A.E.B. continued to stress the relevance of the course to a 'modern' curriculum and explained how the systems approach may be used to introduce skills. Feedback from teachers etc. led to minor modifications so that the draft syllabus contained the objectives given in the first release as four concise aims, the initial abilities were presented as objectives with a slight shift of emphasis towards 'skills' and "application of the appropriate knowledge to new situations". The assessment continued to be on the basis of two written papers and a project; Paper 1 was amended to include assessment of "Application...new situations" and "Analysis and Computation" excluding "Appraisal"; Paper 2 was amended to include "Analysis and Computation" excluding "Evaluation and Judgement and Deductive Skills"; The project had perspective skill added.

6.4.3. Feedback from the Draft Syllabus led to further minor amendments:

i) Safety was placed at the beginning of the syllabus "to emphasise that what is required is a safety conscious approach applied to the whole of the syllabus, rather than an isolated knowledge of safety requirements."

ii) Field effect devices were omitted consistent with the emphasis on Systems made in the Notes for Guidance rather than on Components. At the time, it was considered that the 'system' bias of the '0' level Electronics would enhance its value complementary to the '0' level Physics with its 'analysis' approach. The success of this policy may be judged from the fact that '0' Electronics is now accepted by many authorities as a valid entry qualification, whereas '0' Electricity and Electronics is often placed into a group of subjects from which a candidate may use only a limited number for entry qualifications.

The Notes for guidance were also amended after the release of the Draft to correct minor errors and to omit much of the theory of the Operational-Amplifier once more reinforcing the systems approach rather than a Physics-Mathematics analysis style. The only alteration since made to the final version of the Notes for Guidance was the inclusion of an Addendum being part of the report made by the Chief Moderator in 1982. This reinforced the safety aspects and the need for teachers to give students instructions in report writing. The report indicated that too much work was derived from magazines without any evidence of understanding, consideration of alternatives, testing during development or testing against the specification.

6.4.4 Project Work

The significance of the teacher in project work was noted (6.2.7) and conversations reveal that the teacher could often reinforce his role leading into project work. It would appear that in many instances the student is not made aware of the detail of the project marking scheme by the teacher. This scheme was based on an earlier scheme used for Control Technology and is to be shown to candidates to put the project work into an "engineering context". The Notes for Guidance explain the underlying philosophy and stress that both the teacher and student should understand the requirements of the marking scheme.

Study of the marking scheme shows that the specification of the device or artifact being made by the student is critical. The student is required to submit a Project Brief for approval which contains a clear title for the project with a brief description of its mode of action and four quantifiable parameters. The Brief also requires the student to plan the consequent work by considering the materials, time etc., required, problems to be encountered, tests to be performed etc. The marking scheme indicates clearly that the project does not simply involve constructing a circuit by linking components and/or sub-systems together. A specification can usually be simply derived on the basis of: work students themselves should have done while investigating simple systems, supported by literature sources:

i) What are: the supply voltage?., approximate current magnitude?, thus approximate power used?

ii) If there is an audio signal what frequency range is expected?, how far away might it be heard?, how long for?

iii) If a thermal transducer is used what is its range?, is it linear?, what is the magnitude of its response?

iv) If a square waveform is involved, what is space-mark ratio?, the repitition rate?, is it stable if voltage, temperature etc., are altered?

(Kneale and Snashall 1983-84) discussed several issues relevant to project work, the importance of the articles was shown when A.E.B. reproduced them for issue to A.E.B. '0' Electronics centres.

Thus when the students construct working systems as the course develops they need to be encouraged to explore ideas, to ask questions and above all to test. As (Brandon 1981) wrote "It doesn't matter where you get an idea from - dreams, hardwork, or your local authoritative teacher/text book - what matters and what is pre-eminently teachable, is that you should test it rigorously." Without the use of test equipment a specification can not be established, circuits may be constructed using faulty sub-systems and/or components. Students gain insufficient experience of quantitative data to enable them to develop a confidence in their ability to modify circuits by changing transducers etc. The experiences should lead the students to ask everyday questions: What is the working volatge of a nominal 9v battery? How much power does a battery store? As the battery voltage falls will the circuit still function? It is such curiosity which leads to students to consider alternative designs in journals etc., and to attempt to make either an informed choice or at least to ask questions.

Just as staff on B.T.E.C. courses reported favourably on Moderators, most staff in A.E.B. 'O' level Electronics centres do so also. In many instances the staff lack experience of project work and consequently do not immediately appreciate the philosophy of the 'engineering design context', also very few staff have either an Electronics background or Electronics facilities available.

However, in most cases staff reacted positively to their first experience of the course and sought solutions by contacting

Moderators, attending short courses, generally strengthening resources available to them etc. By contrast with the 'A' level Electronics Systems the 'O' level course requires a lower level of resources and it is supported by I.E.E. workshops and other initiatives such as M.E.P., T.V.E.I., and In-service training schemes.

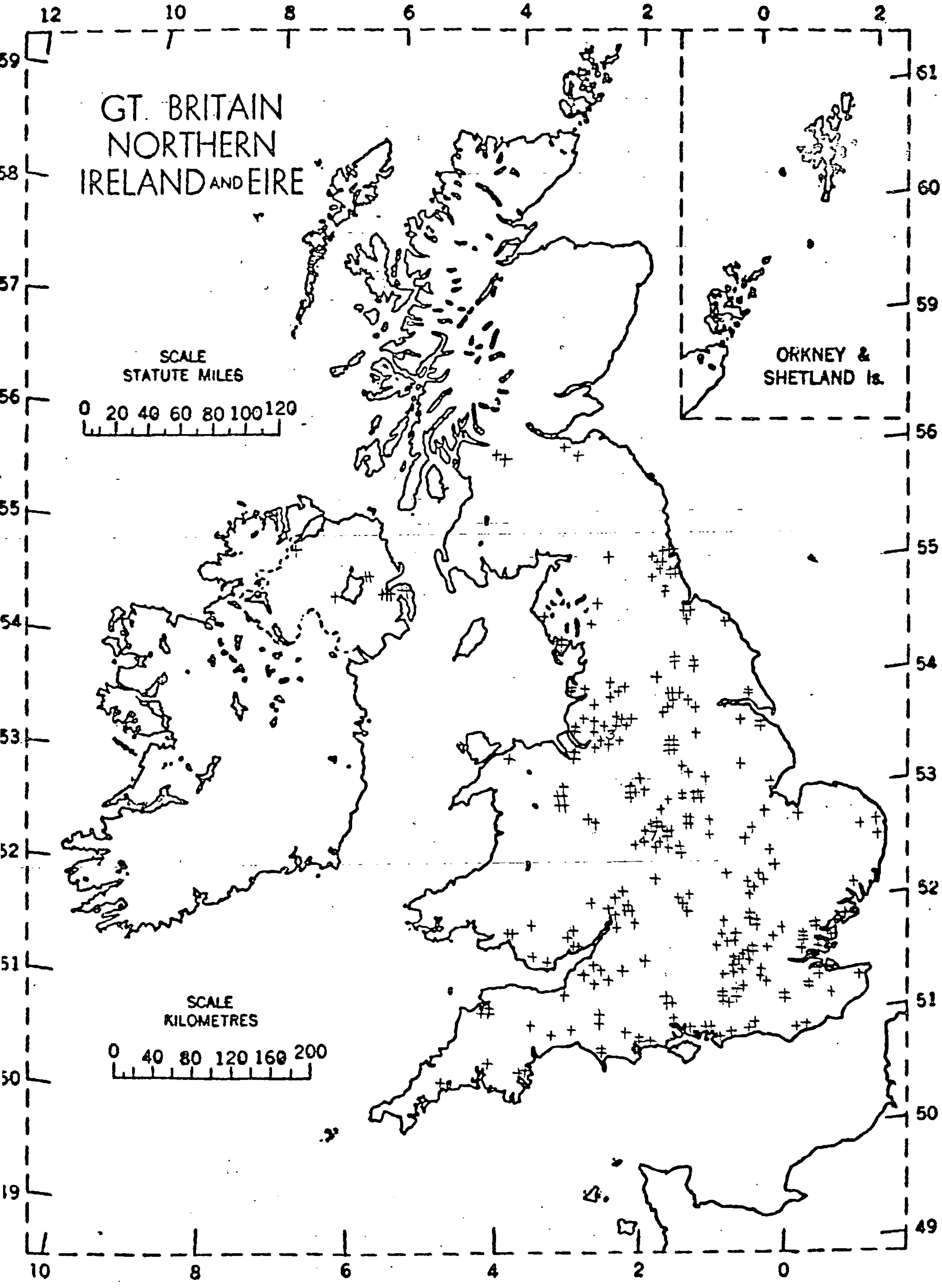
6.4.5 ANALYSIS OF EXAMINATION ENTRIES FOR A.E.B. '080' SYLLABUS

As Map 6.1 shows the growth of the A.E.B. 'O' Electronics attracts nationwide interest. The average number of students per centre in 1985 is ~12 and the subject appears less 'volatile' than the 'A' level Electronics for which 20% drop out of centres was noted (6.3.10) in 1984 of 328 centres; compared with 1983: 64 ceased, 202 started. Provisionally in 1985 of 412 centres, compared with 1984: 66 ceased and 159 started.

In the F.E. sector in 1984, 94 centres out of approximately 135 F.E. centres entered candidates, approximately 30% of the total, being the most popular G.C.E. Electronics course offered in F.E. The average F.E. entry is ~14 compared with schools ~15. The relatively higher acceptance in F.E. than schools probably reflects the capacity in the F.E. sector for time-table innovations, (4.3.1.2) the features noted (6.3.2.3) and the attraction of the subject to more mature students.

This view is supported by the similar acceptance in the Tertiary sector, and the larger Comprehensive schools.

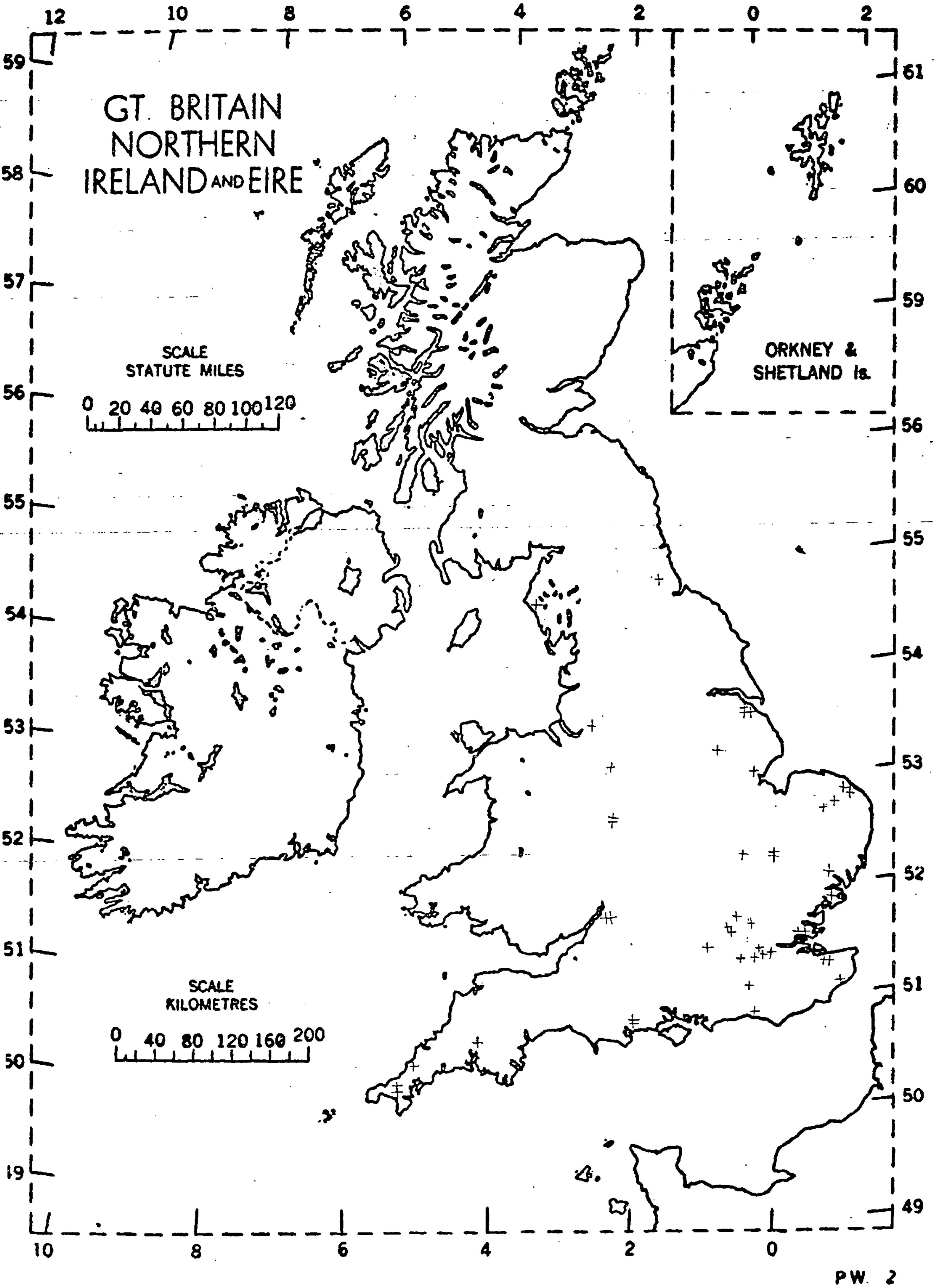
Map 6·1



PW. 2

Location of Centres for the A.E.B 'O' Level Electronics 080.

Map 6.2



Location of Centres for the Cambridge 'O' Level Electricity and Electronics, 7060

Analysis of data also suggests that policy features of some L.E.A.s are encouraging Electronics as a subject vis West Midlands, Devon, Lancashire, London, Hampshire, Merseyside, Tyne and Wear, West Yorkshire and that in some areas the subject is only now beginning to develop vis Northern Ireland and Norfolk. However, the L.E.A. support may be 'not to obstruct' rather than 'to actively encourage'; the high position of Sunderland on Graph 6.6 is such a case. Alternatively the apparent L.E.A. support may derive from their capacity to generate policy change eg. to Tertiary etc. The growth of the A.E.B. 'O' level Electronics is shown in Graph 6.2, Table 6.2.

6.5 ELECTRONICS SYLLABUSES AT '17+'

6.5.1 Four G.C.E. Boards introduced an AO paper either in Electronics or Electricty and Electronics:

1976 London 813 Electricty and Electronics.

1978 Oxford and Cambridge 9670 Electronics.

1983 J.M.B. Electronics.

1984 Oxford 8859 Electricity and Electronics.

All of these syllabuses include a project in their assessment a project which is allocated 20% of the total marks in all except London 813 where it is allocated 25% of the total marks.

6.5.2 Brief details of the London 813 syllabus were given in London G.C.E. Board Circular No. 71 February 1975 and the first examination was held in 1976. The syllabus was given as a series

TABLE 6.2 Examination Boards and Number of Entrants with Year of Examination

EXAMINATION	YEAR OF EXAMINATION											
	85	84	83	82	81	80	79	78	77	76	75	74
O AEB		3600	2250	1670			Actual					
E1	5150	4790	2700				Provisional					
O CAM		418	371	287	276	136	160	184	88	66	57	
E1 & E1	excludes H.M. Forces											
AO LON		1851	1603	1730	1509	1220	807	722	536	290		
AO O & C		354	264	418	209	224	140	109				
AO JMB		422	202									
AO OX		213										
A JMB OPTION E		1809	1724	1707	1527	1370	1227					
A AEB E1 SYST		799	677	593	434	278	181	91	66	58	6	
A AEB EL END		395	288	286	258	221	189	168	128	154	139	175

All Totals exclude Scotland, Channel Isles and Overseas entries of brief headings with explanatory notes. Individual practical work was considered central to the development of the course and the style of the course was implied by a syllabus described in terms of devices. Feedback involved regional meetings of Teachers with the Examiner to discuss project work and the publication of Examiners reports. Evidence of feedback was:

i) Circular 74 April 1975 withdrew the prohibition on candidates taking Phsyics 'O' at the same sitting.

ii) From June 1982 the Case Study requirement was withdrawn and the examination weighting was adjusted:

	Originally	After June 1982
Written Paper	70%	75%
Project	20%	25%
Case Studies	10%	-

(Johnson 1982) indicated that the London AO syllabus was intended to be taught in the sequence:

Potential divider - its behaviour under load.
Diode and transistor.
Extend potential divider to CR circuits and timer.
Logic leading to bi, mono and astuble (7400 series).
Reconsider transistor for a.c. applications.

It was observed that bias, matching and stability were difficult and that these concepts were often introduced too early.

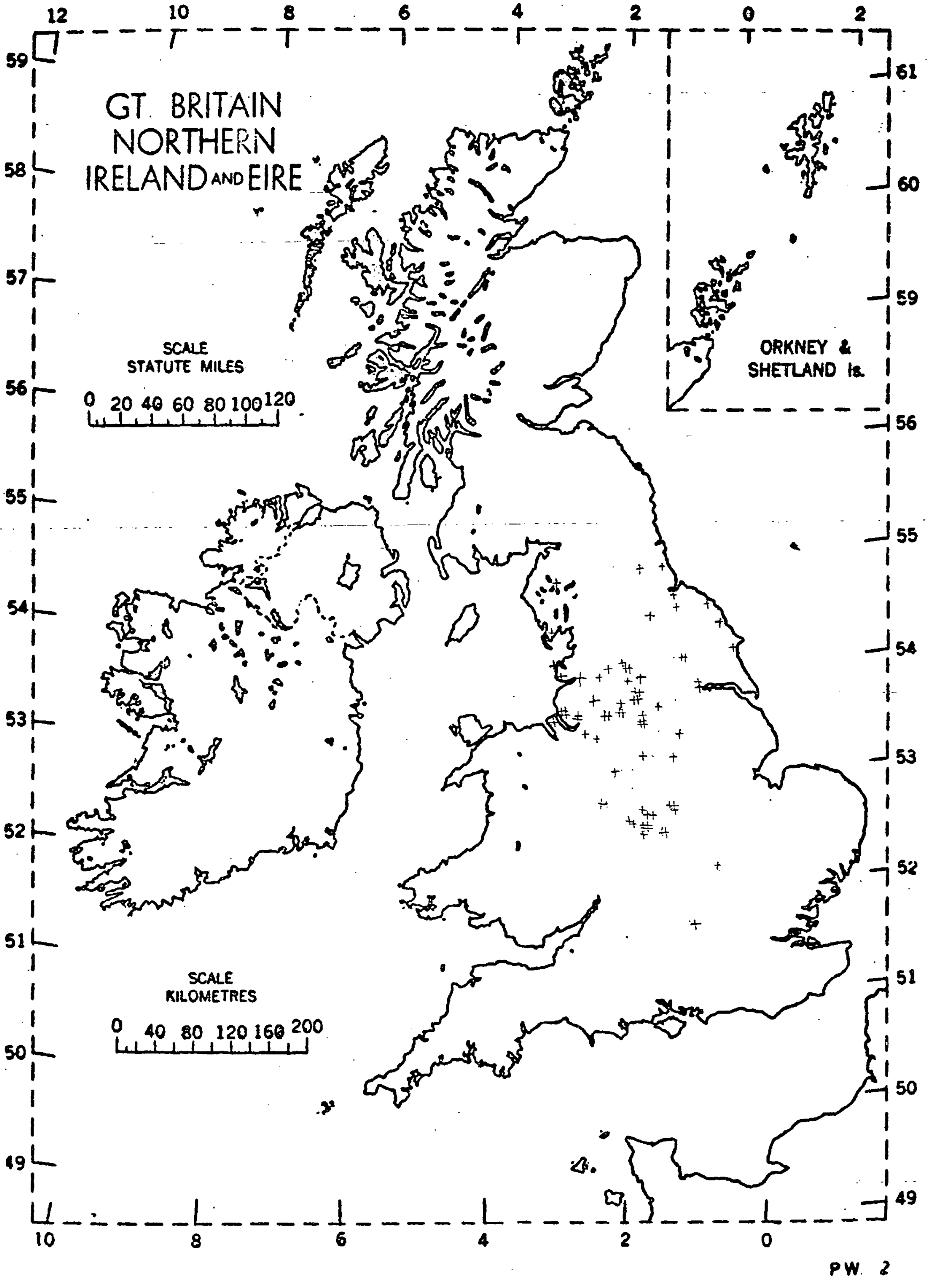
This syllabus commences with devices and is a Components approach similar to that of the Oxford Electricity and Electronics AO 8859 (6.7.3.i) and the Oxford and Cambridge Electronics AO 8670.

6.5.3 The J.M.B. proposals were circulated by J.M.B. and discussed by (Gough 1983). The Board identified growth and interest in Electronics and evisaged support for an Electronics course. However, the Board did not wish to add to the time-table pressure by offering an 'O' level. It was thought that an AO grade would be suited to a wide range of 16+ students. The duration of the course was to be determined by the type of student.

The format of the J.M.B. AO course was more 'modern' than that of the London 813 AO. As (Gough 1983) wrote, Electronics was an ideal area to consider the "... relationship between science, technology and society since the effects are obvious for all to see and happening at such a rapid pace that they are rarely out of the news." This view was reflected in an Aim to "foster an appreciation of the importance of Electronics on current technology and on modern society."

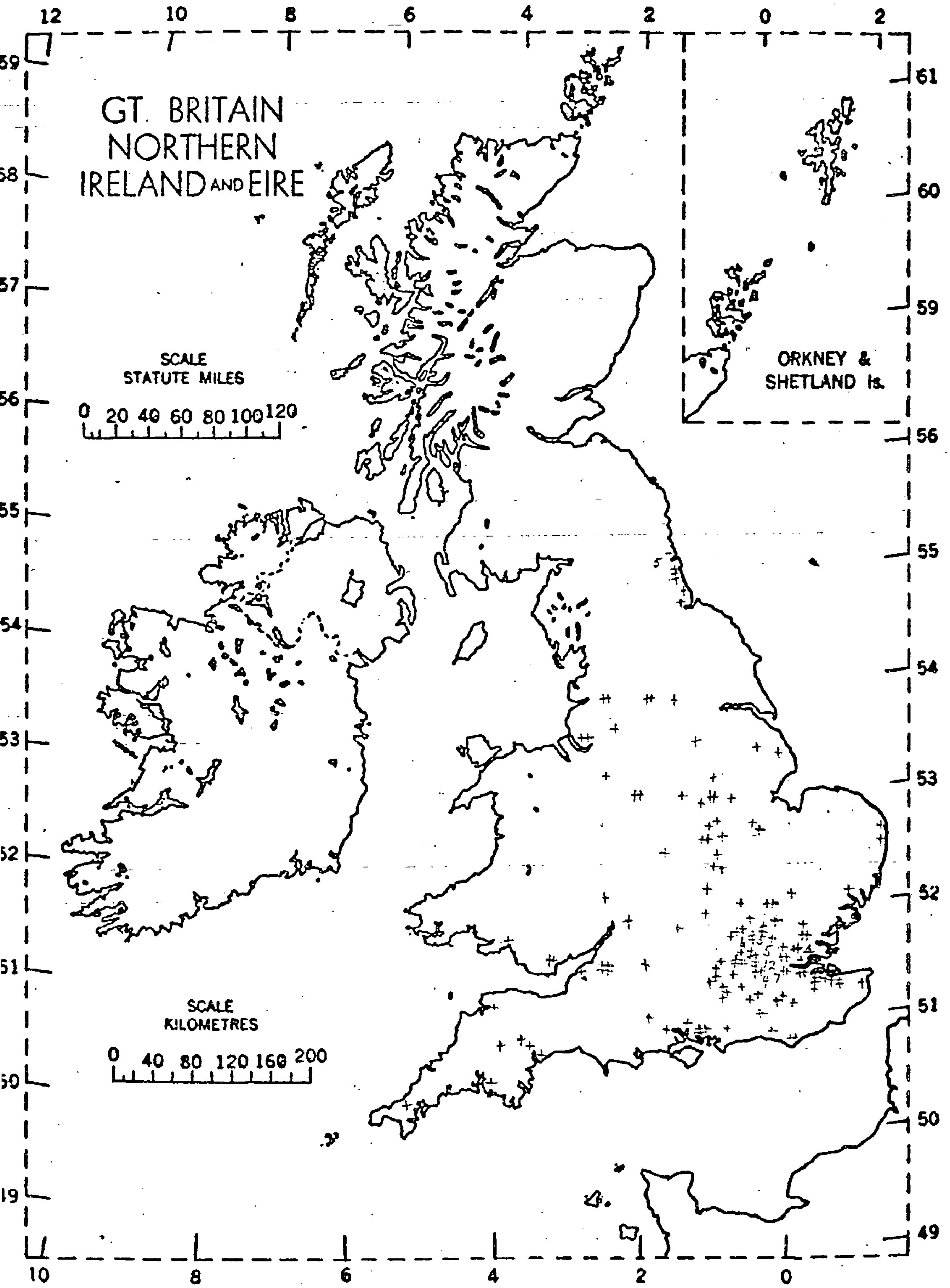
Such an acceptable modern view, the emphasis toward Digital Electronics, the more explicit Aims and Objectives and the support engendered through the J.M.B. structure probably contributed to its growth relative to the Oxford and Cambridge 8670 AO. Indeed it is somewhat surprising that J.M.B. did not introduce the course earlier as the London 813 AO was not supported in Lancashire and the West Midlands, Map 6.4 and the Oxford and Cambrdige 8670 AO was substantially restricted to the Independant Sector. One failure to date is the nil response from

Map 6.3



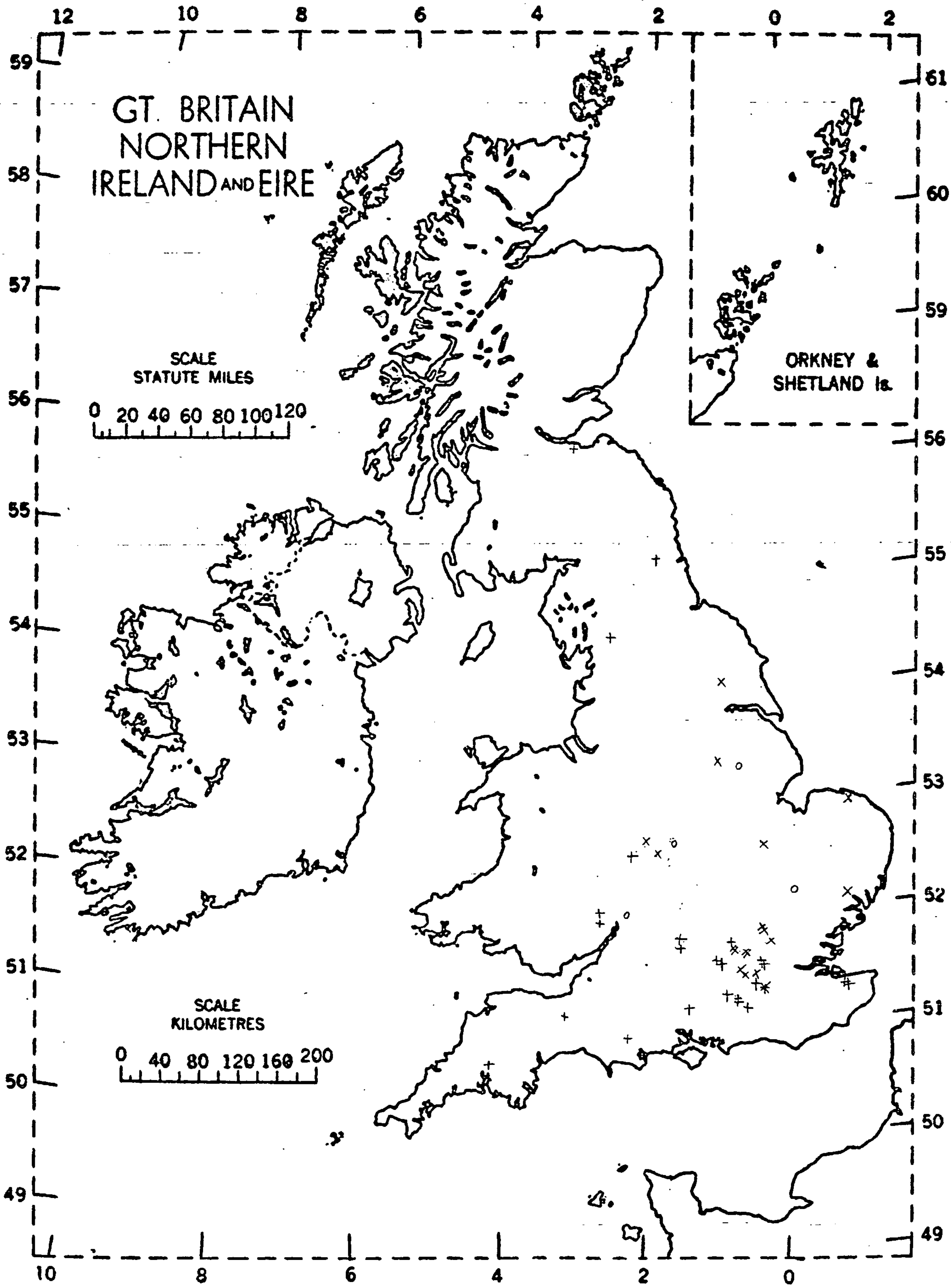
Location of Centres for the J.M.B. AO Level Electronics

Map 6·4



Location of Centres for the London Ao Level Electricity and Electronics 813

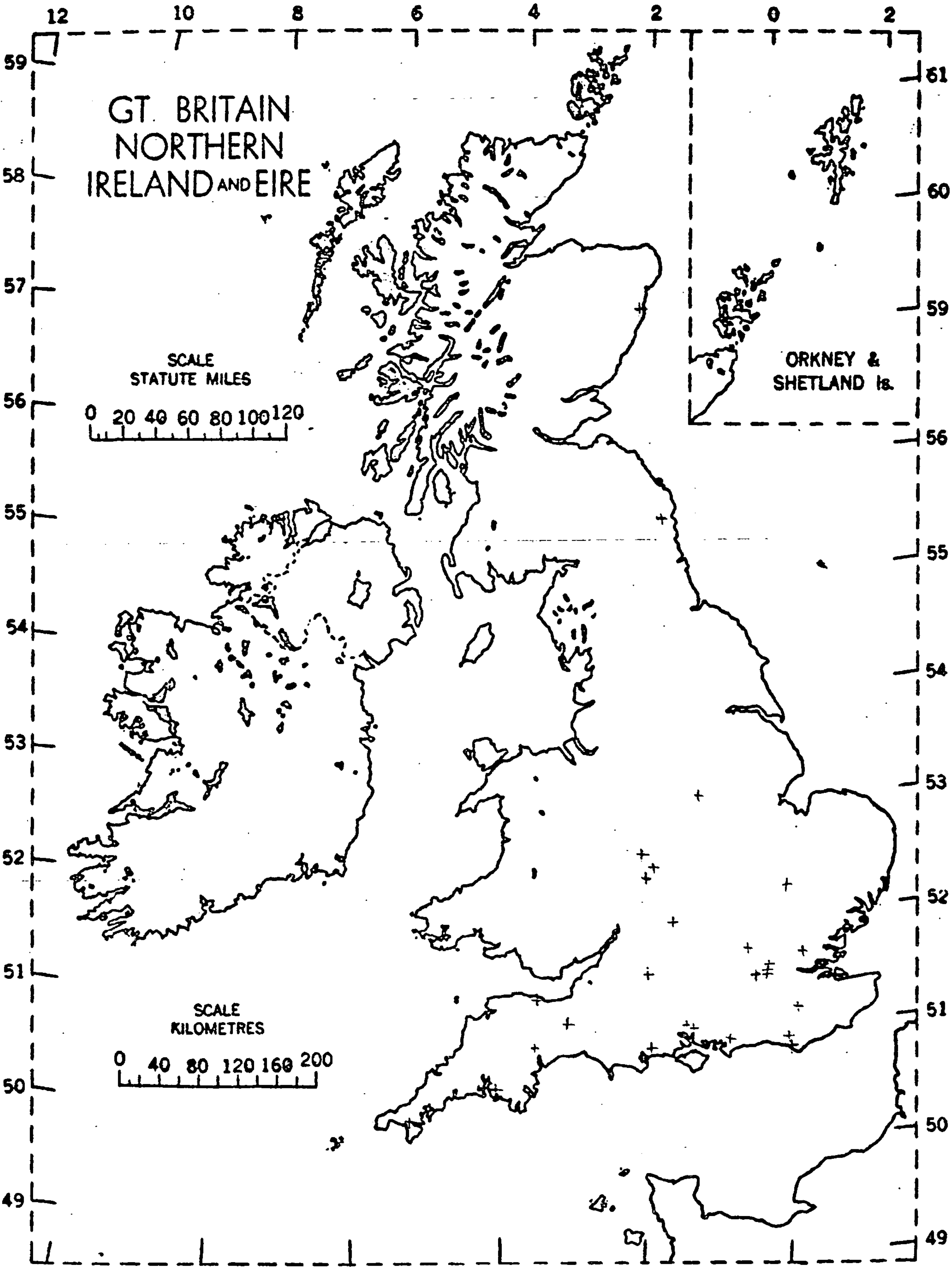
Map 6·5



PW. 2

Location of Centres for the Oxford and Cambridge
A/O Level Electronics 8670
(Oxford +; Cambridge, x; Added o)

Map 6.6



PW. 2

Location of Centres for the Oxford 'AO' Level Electricity and Electronics 8859 the F.E. Sector defined, originally by J.M.B. as a potential 'market'; this however may only reflect changes of the names of centres during educational reorganisation.

6.5.4 The Oxford Ao 8859 syllabus was written by staff at Richard Taunton College, Southampton. By comparison with the J.M.B. syllabus the Oxford Syllabus has a lower subject content, an improved teacher assessment scheme, more flexibility because of its system bias, and it was suggested that it leads into the A.E.B. Electronics Systems. This last factor is a clear example of Houses's pattern of spread, (4.2.10.1), as Bevis the former Director of Studies of A.E.B. Electronics System was also associated with Richard Taunton College. It is also significant that the proposed Southern Examining Group includes the A.E.B. and Oxford Board, so that the introduction of an AO grade would offer experience at all levels to the new examining body.

6.5.5 Analysis of AO entries

Study of the AO syllabus show changes in content, format, and presentation similar to those generally noted by (Galton and Eggleston 1979): "Each subject curriculum had its own philosophy embedded in a statement of aims, they had in common the intention of moving away from the traditional view of science as taught in schools, as a set of received facts and principles." The AO Electronics courses involved new ideas which were being continually updated and students were required to explore the new ideas.

Graph 6.3, Tables 6.2, shows that total growth in AO Electronics has accelerated slightly, the total spread of entrants broadly covers the entire country. All of the Boards attract only small numbers of entrants per centre, only J.M.B. data was examined to determine the 'volatility' of examination centres.

A comparison of the J.M.B. entrants for 1983 and 1984 shows in 1984 71 centres of which compared with 1983 (9 ceased and 48 started). That 9 centres ceased out of a total number of 32 centres in 1983 is masked by the total overall growth and once again demonstrates the 'volatility' of the situation.

Table 6.2 suggests that centres do move to other syllabuses as they become available.

Table 6.3 shows that only a small percentage of the centres are able to link an AO Electronics course to an A Electronics course as suggested (Electronics Systems News, May 1983, 18). The AO coding reflects that the course may be suitable for more mature students, however, the AO qualification is only given credit as an '0' level for entry qualifications.

It is interesting to note:-

i) Many more F.E. centres enter the A.E.B. '0' level Electronics than the AO Electronics examinations.

ii) 26 State Schools and 32 F.E. centres offer both the A.E.B. Electronics and an 'A' level Electronics.

These facts suggest that the '0' level is just as acceptable as the AO level for mature students, also that the F.E. centres can

TABLE 6.3 Details of AO Electronic Examinations

Examination	Summer 1984 Examinations		
	No of Centres	Average No of Entrants per Centre	Regional Spread
London	221	7.1	London, Home Counties, East Midlands, a few from the S. Coast and N.E. England
O & C	46	7.7	London and Home Counties (1)
JMB	70	6.3	Lancashire, West Yorkshire, West Midlands and Birmingham, a few from N.E. England
Oxford	26	7.7	Scattered over Southern England

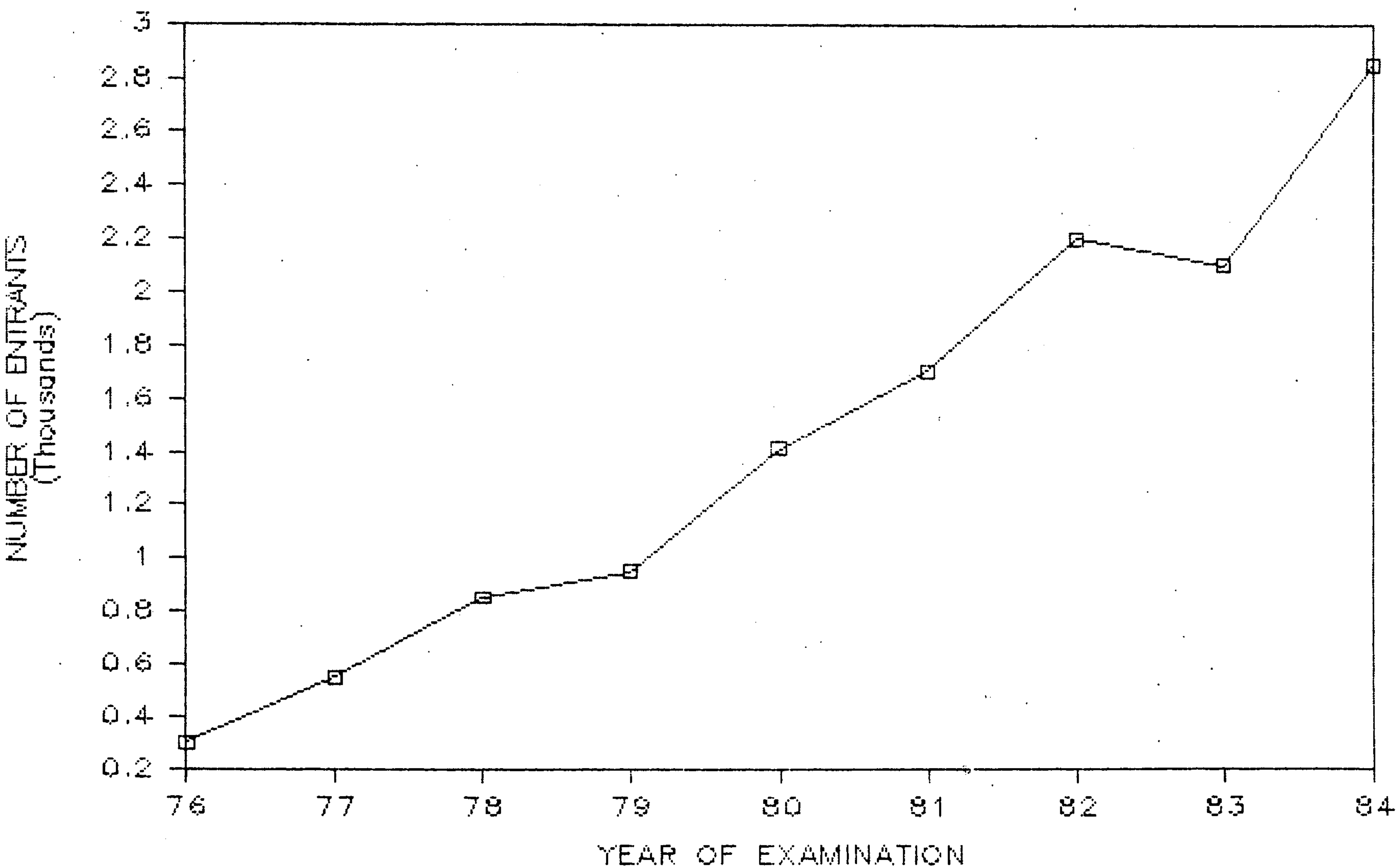
1. A slight scatter represents the popularity of this Board in the Independent Sector where 38 centres enter candidates.

Examination	Summer 1984 Examinations			
	Type of Centre and No	No also offering 'A' Electronics		
		Systems	End.	Systems and End.
London (2)	FE 23	5	2	-
(3)	State School 183	13	5	1
Oxford (4)	State School 26	6	-	-

Centres also entering 'A' level Electronics are:

2. mainly in the London area;
3. mainly in the London, Hampshire, Tyne-Wear areas;
4. mainly in London and the South.

GRAPH 6.3 TOTAL "AO" EXAMINATIONS



offer a broader range of subject choice.

6.6 ELECTRONICS IN 'A' LEVEL G.C.E. PHYSICS SYLLABUSES

6.6.1 Nuffield Physics

The Electronics content of 'A' level Physics syllabuses was a significant factor in the introduction of Electronics into the curriculum. Reference was made (6.3.9) to the Nuffield A level Physics Unit 6 'Electronics and Reactive Circuits'. The Unit was designed originally "on the assumption that many more students will be users of electronic systems than will be designers of electronic circuits." Using a black box approach a transistor was introduced for switching, amplification etc., and other useful behaviour. (Harris 1985) described the revision of the Nuffield A level Physics for a 1987 start which was intended to:-

i) cover the existing core and add new topics.

ii) have a new format.

iii) without major expense introduce some new equipment.

iv) provide a role for microcomputers.

The content of Unit 6 is now covered in Unit C 'Digital Electronic Systems'. However the presentation is now based explicitly on logic gates (NOR and NAND) rather than on a 'basic unit'. To minimise expense the original basic unit may be used with two NAND gates, (Harris 1984) reviewed a suitable kit.

Unit 1 'Linear Electric Feedback and Control' is new to the syllabus and is largely based on the operational amplifier. This unit provides an introduction to devices and basic control principles as well as providing an opportunity to use and revise "some basic ideas about electric circuits, oscillation, growth and decay."

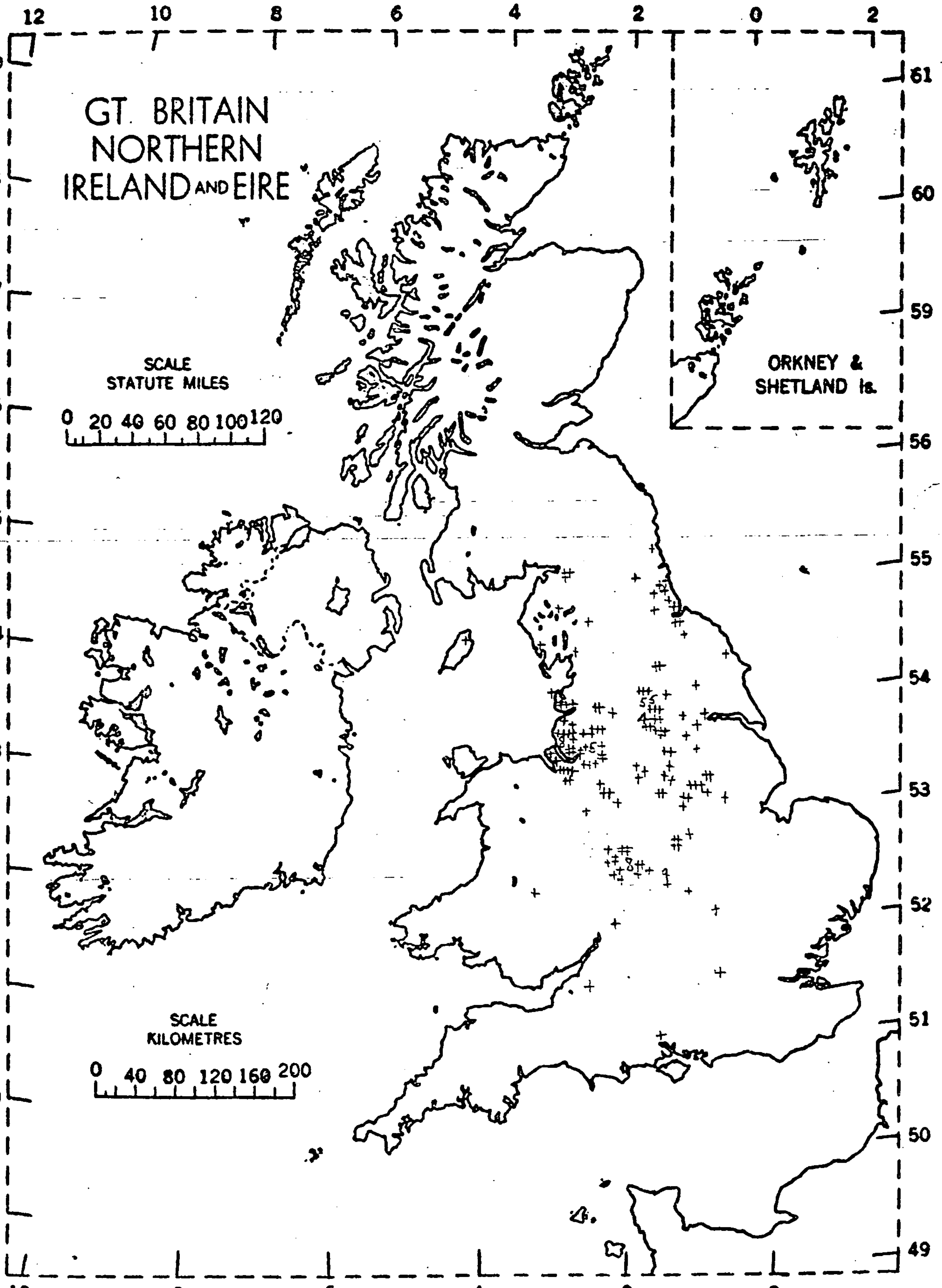
These units are to be covered in three weeks, and a "major innovation" to ensure wide reading in this coverage is the provision of a new student guide.

(Ogborn and Wong, 1984) described a Dynamic Modelling System for use on the Nuffield course. This microprocessor allows students to obtain solutions to problems by writing out equations, also it includes a range of programmes vis: S.H.M., electric and gravitational fields. This simulation approach is novel within an 'A' level syllabus and it relates to proposals made by (Sparkes 1985).

6.6.2 J.M.B. Physics

The J.M.B. 'A' level Phsyics syllabus prior to 1979 included the C.R.O., diode and rectification. In 1979 a choice of options was allowed, one of which was Option E, Electronics. The basic syllabus now included the C.R.O. bridge rectification and use, input and output characteristics of one current and one voltage amplifier, also switching and inversion. The option E syllabus included transducers, matching, simple logic, use of operational amplifiers, the effect of feedback on the performance of amplifier, Multivibrators etc. As many of these topics were outside the experience of many teachers, the J.M.B. Sub-Committee for Physics issued 'Notes for the Guidance of Teachers on the

Map 6·7



PW. 2

Location of Centres for the JMB Section E, Electronics of the 'A' Level Physics.

Electronics Option' in March 1977.

Other than a minor proof correction the next change occured in 1981, the Option E syllabus was retained within the 1986 revised syllabus. The operational amplifier was given greater coverage, logic was extended to include a comparison of all flip-flop action and a binary 4-bit counter. The operational amplifier was no longer applied to second order differential equations.

This option showed a slow growth within the total pool of J.M.B. 'A' level Physics students from approximately 9% to 11%, figures are shown in Table 6.3.

6.6.3 London Physics

The London 'A' level Physics syllabus up to 1973 contained thermionic emission, the C.R.O., diode and triode Commencing 1973 students took a Part I core with one of the two sections in Part II. The content of Part II included:

i) semi-conductors, effects of impurity and temperature including band theory.

ii) simple amplifier and rectification, either thermionic or solid state.

iii) C.R.O.

From 1973 to 1977 the form of the examination and the format of the Regulations and Syllabus were progressively altered. The syllabus was no longer in two parts and it included brief notes, and syllabus weightings relevant to Blooms taxonomy were given.

Commencing June 1977, the only thermionic device was the C.R.O., Band theory was omitted, although either the junction transistor or F.E.T. device could be taught only details of the common emitter mode amplifier were required, and the syllabus no longer specifically mentioned rectification.

For examinations to commence June 1983 up to January 1987 the electronics content was further amended to restrict semi-conductors to Group IV; the terms electrons/holes and extrinsic were included; specific reference was made to the p-n junction, diode rectification and smoothing; only the bipolar transistor is required both as a common emitter Class A amplifier and a switch.

6.6.4 Summary

Thus the electronics content of all three 'A' level Physics considered continually evolved from thermionic to solid state devices requiring an updating of teacher skills and equipment. In comparison with 1973, the teacher is now offered aims, objectives etc., which are more specific in terms of scope, terminology and exam intent, thus attempting to avoid aspects of the 'hidden-curriculum', (Crellin et al, 1979, 684-5). There is evidence of Application rather than Knowledge in all cases eg. London: rectification, smoothing, specification of amplifier class, and switch, and instrumentation/communications options in 1987. This change and the move towards logic gates and the operational-amplifier, eg. Welsh Board, doubtless keeps the syllabus 'modern', and therefore acceptable to students. Insofar as the syllbus revision is fundamentally top-down doubtless the resultant syllabus is also acceptable to higher education, professional bodies etc. (4.3.5.8).

It is significant that although the London Board continually made minor adjustments of detail neither they or any of the other Boards concerned made changes requiring further purchases of equipment within a short period. Indeed the Boards showed an awareness of the limitations of resources in terms of teacher skills and materials, for example, the change by Nuffield to include the microprocessor is the only major change. An awareness was shown also when in general only, either 'easy' or 'standard' questions were set on the semi-conductors etc., when they appeared in the syllabus, (Crellin et al, 1979, 706).

6.7 Other Exmination Boards Include:

6.7.1 City and Guilds

Courses involving Electronics relevant to the 14-16+ age group:

i) Electronic Servicing 224

ii) Microcomputer Technology 756

6.7.2 C.S.E. and C.E.E.

Restrictions of space and time compel comment to be brief. The data given in the Appendix shows several Boards with a long-established involvement with Electronics with a total pool of students comparable to A.E.B. 080. The number of entrants shows a continuous growth interrupted in 1982 and 1983, presumably by the introduction of A.E.B. 080, and then resumed growth. The weakest group is that in the North.

Electronics is offered under a wide variety of titles, especially by the N.W. Regional Examining Board. The syllabuses are usually Mode 3, although the East Anglian Board offers a well supported Mode 1 and the Southern Regional Examining Board shows a shift from Mode 3 to Mode 1. The latter shows a major growth 1981-1984, probably reflecting local support following the review of the previous syllabus.

In general syllabus content changed towards a 'modern' approach as evinced by those Boards previously discussed.

6.7.3 Oxford Delegacy of Local Examinations

i) Electricty and Electronics AO, 8859, introduced 1984.

In comparison with the alternative G.C.E. AO Electricty and Electronics syllabuses the 8859 is an 'Electronics' syllabus. The only unusual feature is the definition of the Systems Approach may start from "a knowledge of circuit theory and component behaviour". This is not in agreement with either the description of the systems approach given in 6.4.2, or the description given by writers such as (Geddes 1984, 268-270), (Foxcroft 1983, 4-5) and (Foxcroft 1984, 32-33).

ii) Electricty and Electronics 'O', 5859.

This syllabus may not be entered at the same time as 8859 which is intended for more mature students. The content and presentation of the syllabus are conventional but the assessment differs considerably from those used by other Boards for this subject. 50% of the assessment will be by the teacher comprising

30% Project/Investigation/Extended Article and 20% Coursework, the marking will not be moderated instead a proportion of the centres will be visited by the examiner. The criteria and mark ranges given by the Board offer very little guidance especially to a 'new' teacher and compare unfavourably with other schemes especially in view of the high loading involved.

6.7.4 Cambridge Local Examinations Syndicate

i) Cambridge Electronics 'O' level 7065 to be introduced in 1986 jointly with Oxford and Cambridge. Compared with the 7060 Electricity and Electronics, the 7065 syllabus is completely different in that a project worth approximately 18% of the marks is included and a systems approach is used. The syllabus is presented in three sections: 'Current Concepts, Devices and Transducers', 'Digital Circuits' and 'Analogue Circuits', with the emphasis on digital and analogue I.C.s. The syllabus is in general similar to the A.E.B. 810; the presentation is not supported by detailed Notes for Guidance in particular the project marking scheme of Cambridge appears as a precis compared with the A.E.B. scheme.

ii) Cambridge Electronics 'A' level 9363 jointly with O and C to be generally introduced in 1986. The syllabus was developed in collaboration with O and C to link with the O and C AO Electronics and the 7065 'O' level Electronics. It was envisaged that students could "set out with the one-year AO course in their sights and move on in their second year to continue with this 'A' level course".

The course is basically similar to A.E.B. Electronics Systems 658 except that the systems approach is not related so closely to human and other systems as is advocated by A.E.B. Project work is included in the form of two projects each equivalent to fifteen hours work allocated 7% and 13% of the total marks respectively.

The 9363 course was supported by documentation which although not as detailed as that from A.E.B. is usefully complementary, eg. whereas A.E.B. provides a list of suggested projects the Cambridge Board distinguishes between the four categories of practical: investigation, synthesis, application and problems in a way that many teachers will find useful.

iii) The Cambridge 'A' level Technology and Electronics contains an Electronics module which introduced discrete components such as the operational amplifier, display devices and intergrated circuits which were then used in control systems. The J.M.B. 'A' level Engineering Science also has an Electronics content.

6.7.5 Craft, Design and Technology, C.D.T. courses

Report 18 of the Schools Technology Forum 1979 described the response of the Schools Technology Forum and the Science and Technology Regional Organisation (S.A.T.RO.) to meet 'Employment Needs'. An active initiative in schools was called for with five aims:

i) "pupils <u>handle and become familiar</u> with technological components and devices -- transistors, amplifers -- switches -- instruments -- integrated circuits etc."

ii) "pupils develop a knowledge of the ways in which such devices are used in the design of systems---"

iii) pupils develop the capability to tackle technological problem-solving in the design and creation of working engineering systems.

iv) pupils develop the capacity to use their science and mathematics in the design of working engineering systems.

v) pupils experience the excitement of successfully overcoming the hurdles on the way to creating a device which meets a specified need.

The Report then indicated how Technology teachers could participate in Microelectronics describing a Programme which was fundamentally a Proliferation of Centres Model. It was suggested that the Research, Evaluation and Dissemination phases would take three years from commencement and three parameters were identified against which individual schemes could be evaluated:

vi) people involved.

vii) types of activity.

viii) areas of implication.

The consequences of this and similar initiatives was illustrated by a report by (Pilliner 1985) on a proposed modification in the A.E.B. 'O' level Control Technology. Whereas the present course involves 'relay logic and presentation' the proposed scheme allows 'computer system and interface' as an alternative. A Mode

3 pilot development supported by M.E.P., N.C.S.T. took place in 1984 which will lead to extended trials in 1985 followed by a full pilot evaluation in 1986: (Ghee and Mills, 1985), (Pike 1982, pp.17 - 18).

The course is not specific to a particular microprocessor chip and it involves the use of the microprocessor for simple operations and procedures to control hardware making it work as intended. The skills involved are those involved in A.E.B. 'O' Electronics and in terms of design etc., the course allows that for a given task the microprocessor may not be the best option so that alternative solutions are acceptable in examinations.

Thus although the present A.E.B. Control Technology or indeed the Southern Universities Joint Board 'O' level Technology were not included in the survey because of restraints of space and time, it can be seen that the C.D.T. syllabus content may be covergent with the Electronics syllabus.

6.7.6 AS Levels

These are to be introduced in 1989 to coincide with the withdrawal of AO level examinations. Discussions on Advanced Supplementary (A.S.) levels may lead to 'complementary' studies for science students and 'contrasting' studies for non-science students. An approach which (Fairbrother 1984, 42) doubted as it was contrary to the philosophy of the A.S. grade which was to relate it to its correspodning 'A' level syllabus. It is possible that the curriculum could be broadened by using modules from the C.P.V.E. programme or by adding addition materials to such units. The C.P.V.E. syllabus offered by Southern Regional Board suggest that Electronics may be usefully included in such 'supplementary' studies (Section 7). The 'first priority' proposals did not include Electronics and as the D.E.S. suggest that provision must be made within the total resources available rapid growth of Electronics in this sector is doubtful.

6.8 ANALYSIS OF ENTRIES

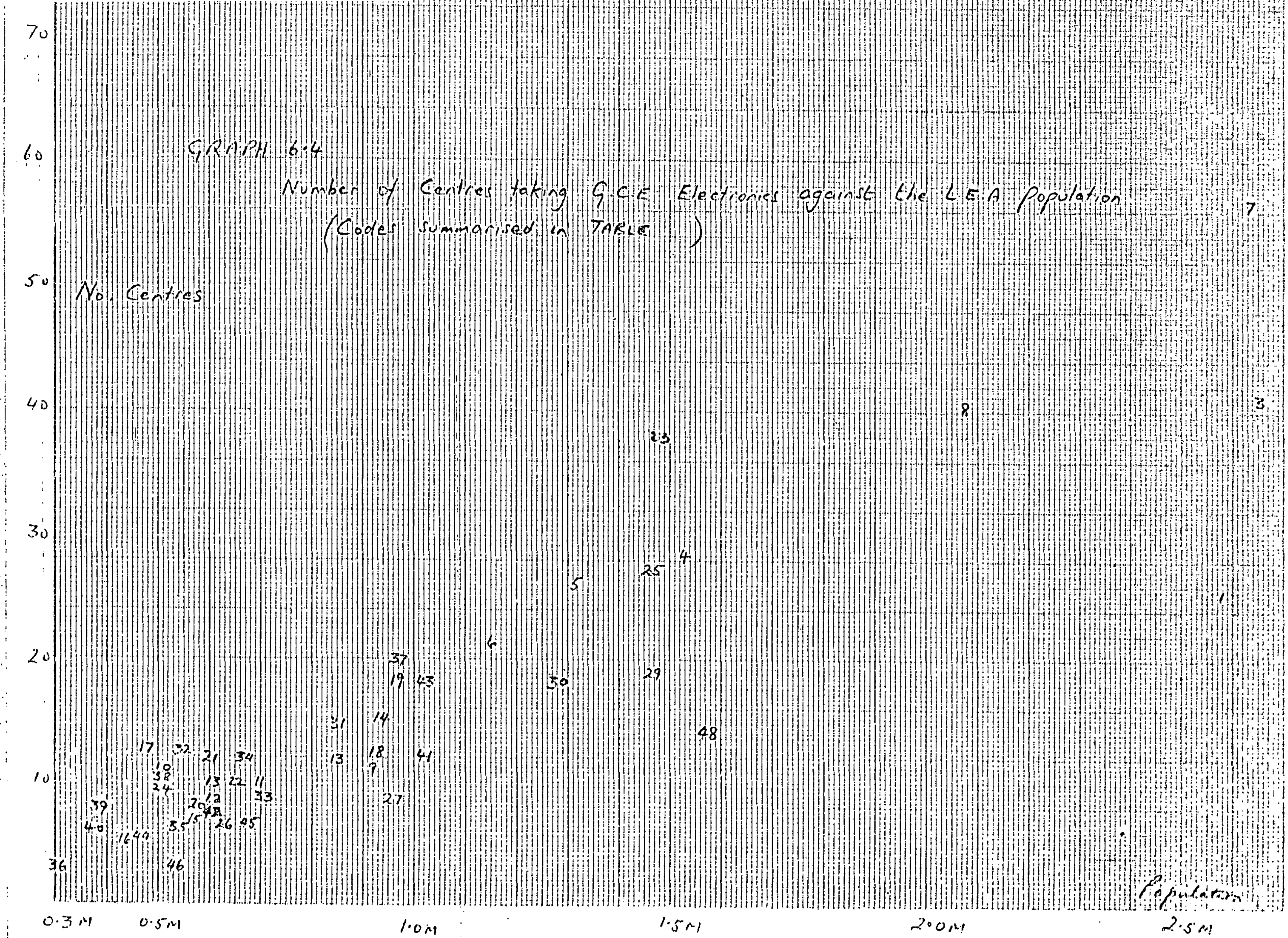
The A.E.B. 'O' level Electronics shows a broad geographic spread of entries, Map 6.1, and it was chosen for an analysis of the significance of examination centre size. 94 F.E./H.E. centres each have approximately 19 entrants, 21 Sixth Form and Tertiary College centres have approximately 18 entrants, the School centres have approximately 11 entrants. These figures suggest that the large centres can provide large viable groups (4.2.3). However, a much lower proportion of the Sixth Form and Tertiary Centres enter candidates than do F.E. centres so factors must be involved other than the size of centre and maturity of student. Also reference was made (6.3.2.3) to the necessity for F.E. to attract students. No data is available for either B.T.E.C. or City and Guilds but in many regions it can be anticipated that numbers on day release courses involving Electronics declined in consequence of reduced employment opportunity for technicians. The growth of the A.E.B. 'O' level in F.E. probably reflects that many young unemployed students are selecting 'instrumental' goals: (Rutter 1979, 15), such as examination success and preparation for jobs. Also the data suggests that in some regions it is L.E.A. policy to place Electronics provision in the F.E. sector eg. Wales, Northern Ireland, Buckinghamshire.

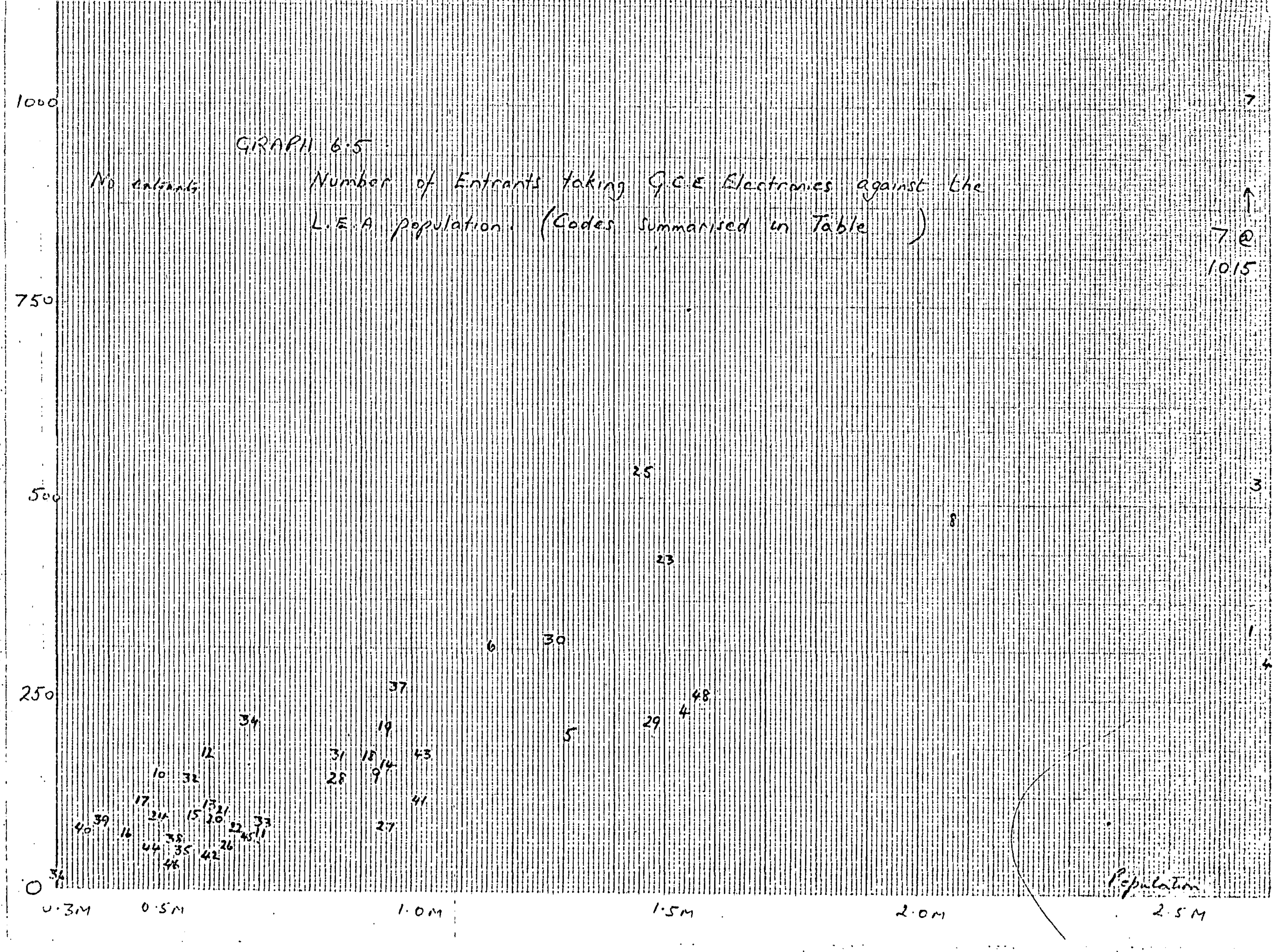
Graphs 6.4, 6.5 and 6.6 show that the number of examination entrants approximately equates to population, eg. Graph 6.5 has a slope og +223 entrants/Mill.population, intercept -32.2, and correlation coefficient 0.81, suggesting that L.E.A. policy is not itself a major influence (4.2.9.2). The distribution on this graph shows no correlation with the pattern of annual costings of support, premises etc., given by (Lord 1984, 36) who indicated other significant factors similar to organisational health (4.4.1).

Reference was made (6.3.10) to the possible value of accumulated resources and these may be much more significant than an annual figure as given by Lord. Whether with the active support or acquiescience of the L.E.A., a 'critical mass' is required for a successful local project. (Johnson 1982) in connection with Electronics courses suggested that at a certain stage of competence an enthusiast with journals etc., and with a minimum formal training 'takes off'; this view is suggestive of House's 'critical mass'. The 'volatility' of centres may indicate that some centres may become involved without reaching the necessary level of resources etc. (4.3.1.1).

6.9 CONCLUSION

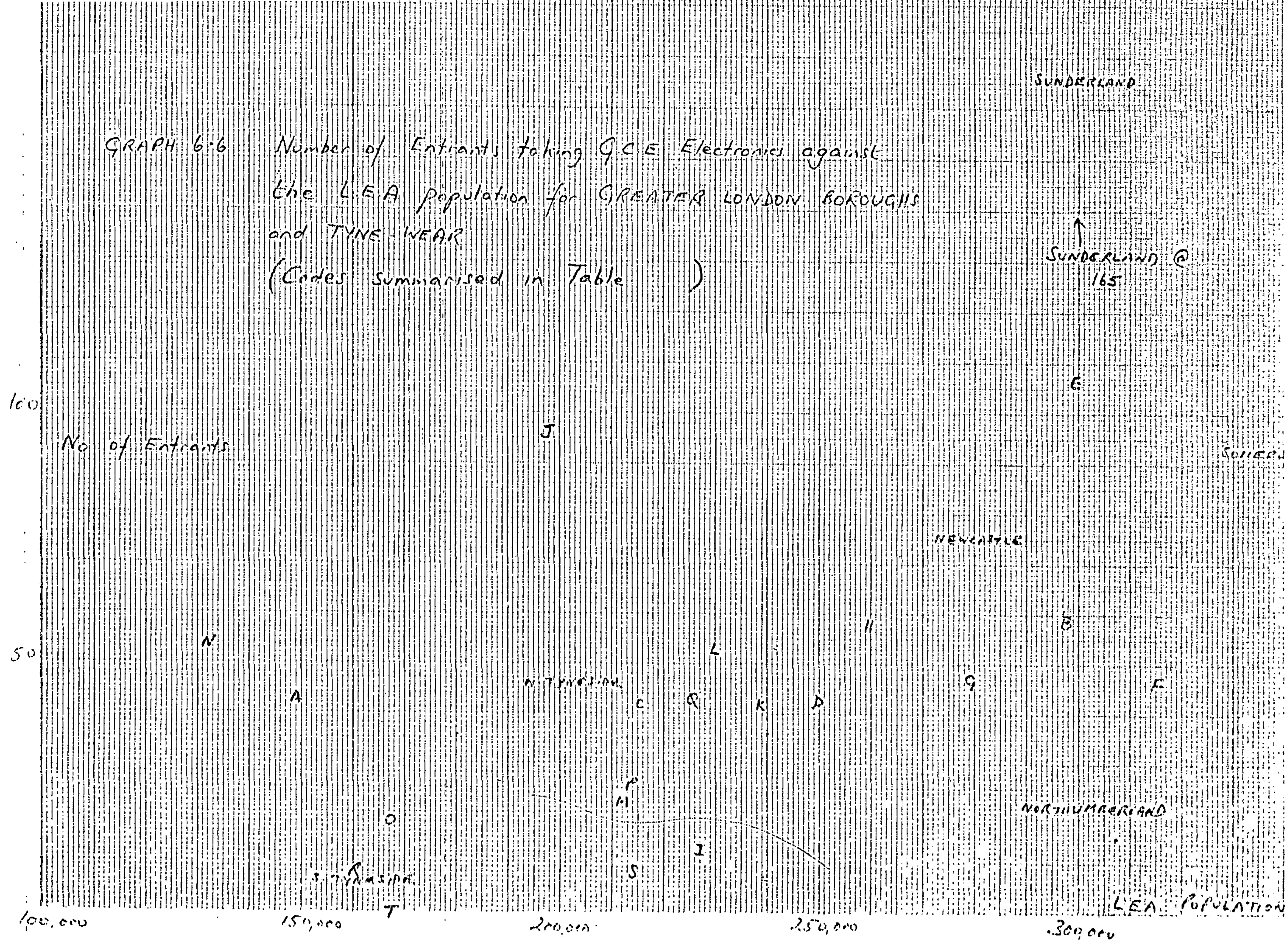
(West 1983) wrote "Whilst many would not conceptualise the school examinations boards as change agents". The evidence does suggest


GRAPH 6.4
Number of Centres taking G.C.E Electronics against the L.E.A Population
(Codes summarised in TABLE)
No. Centres
70
60
50
40
30
20
10
0.3M
0.5M
1.0M
1.5M
2.0M
2.5M
Population



GRAPH 6.5

Number of Entrants taking G.C.E Electronics against the L.E.A population. (Codes summarised in Table)



GRAPH 6·6 Number of Entrants taking GCE Electronics against the LEA Population for GREATER LONDON BOROUGHS and TYNE WEAR (Codes Summarised in Table) that they and B.T.E.C. are indeed change agents quite capable of pursuing initiatives in conjunction with professional institutes, other examination bodies etc., rather than wait for central government support. In doing so the Boards are able to rely on the strength of their formal qualifications and the enduring parameter of the exam system: (Salter and Tapper 1981, 127).

7. RECENT INITIATIVES IN EDUCATION RELEVANT TO ELECTRONICS

'You cannot teach a crab to walk straight'
Aristophanes, Peace, 1,1083.

A consequence of increasing central control of education, (Section 5) is that various agencies of Government Departments such as D.E.S., D.T.I. and to some extent D.H.S.S., are now attached to the body of Education in an education/training role.

This Section describes the initiatives of some of these agencies in the field of electronics. The progress of the M.E.P. is compared with the detailed innovation strategy suggested at the inception of this Programme. The M.F.A., T.V.E.I. and S.S.C.R. are briefly described and their potential impacts on the Electronics 16+ examinations are considered in terms of resources. The viability of Regional provision for 16+ Electronics is considered and consequences are suggested.

7.1 MODERN INNOVATION THEORY

7.1.1 The formal R D and D model described (4.2.8.1) was found to require the use of strategies if it was to be effective: (Section 4) Thus recognition of the problems of teachers, local difficulties etc., required an advance in the basic theory of diffusion to allow for social learning theory. Such an advance came from the work of (Guba and Clark 1975); they reported:

i) the centre-periphery model had set unreasonable targets and had changed its policies too frequently.

ii) the central control should be diminished within a realistic complete programme for education, knowledge, production and utilization, (K.P.U.).

iii) such a K.P.U. programme was to be "responsible to both individual (ideographic) and instructional (nomathetic) goals" across a broad field of education.

7.1.2 (Berg and Ostergren 1977) also tried to place the formal R D and D process into a social and organisational context identifying:

i) Gains and losses, of both security and stability, and and self-satisfaction.

ii) Ownership, is there an identity to innovation by the teacher?

iii) Leadership, characteristics of the leaders, sub-leaders and the "opposition".

iv) Power, emphasising that institutions are essentially conservative being defensive against intrusion.

Berg and Ostergen advised (p.6), there should be "clear gain and few losses to be made, a strong sense of ownership, effective leadership and more importantly a sensitive and timely exercise of constitutional power that could be mobilised to secure the innovations. They also advised that innovation processes were dynamic and the factors which they had identified might change with time. (Coulson 1983) described the changes which had occured in U.S.A.

(Barton et al, 1980, 7) offered a much simpler explanation for the failure of innovation models when referring to Musgrove's concept that without a dominant group a lasting 'hegomony' can not be achieved. Thus the vagaries of elections have national as well as local educational consequences!

7.1.3 (House 1974, 97) discussed the economy of school innovation work and how the system could be changed making two suggestions:

i) use of 'Merit Pay': the administrator decides differential access to information and rewards. It was thought that this approach would enhance administration power leading to "more frequent, though more limited" innovation.

ii) an increase in the "relative power and influence of the teachers" of which the more virulent form of the strategy would be to promote professional contact and interaction outside the school: House considered that teachers could bargain for innovation resources and rewards leading to "more varied pluralistic innovation that would be more widely and deeply embraced by all organisational members.

The second strategy was supported by several writers. (Hunter and Heighway 1982) described the role between Headteacher and ordinary teacher as becoming blurred allowing a 'creative turbulence'. (Munro 1977, 58) stated some evidence suggested that to get improvement in educational practice "the restricted roles of schools and teachers cannot be allowed to persist". (Rogers and Marcus 1983, 256) wrote: "local control is needed for maximum committment to innovation and that the Government should support the social learning process by providing support from peers in local teachers centres.

7.1.4 (Miles 1965) proposed that a network of teacher centres could allow "low energy access to trusted competence". Appropriate information energy and other resources can be easily located from physically dispensed modes to solve local problems. It is pertinent to note that (Miles 1964, 643) identified advantages in the creation of new innovative structures to by-pass vested interests:

i) due to limits on the length of time of appointments increases creativity, involvement and work level.

ii) has a minimum bureaucratic restriction and does not involve role-conflict.

iii) can deal with specific, short run problems expeditiously.

iv) provides a reasonable link to target.

A disadvantage identified by (Miles 1975, 477) was that the by-pass could itself become elitist.

It was against this background of opinion moving in favour of models other than R D and D, that the new training initiatives to be discussed were introduced.

7.2 GENERAL FEATURES OF CURRICULUM CHANGE

Whereas the G.C.E. and B.T.E.C. Examination Boards exert a 'top-down' influence on curriculum many of the new training initiatives advocate a 'bottom-up' approach. At present there is no clear consensus of opinion on the suitability of these two approaches to the Compulsory School curriculum in terms of their academic, professional and vocational significance. Indeed (Tomlinson 1985, TES, 22-2) wrote "At the same time the conceptual split sharpens between education, (characterised as soft, person centred, academic, analytical traditional, a consumption good rather than investment) and training (hard, task-centred, practical, innovative and a national investment)".

Reference was made in Section 6 to the importance of introducing problem solving skills in an everyday relevance and this is offered as a basis for vocational initiatives. It is suggested that vocational work may usefully bridge schools with industry and commerce to the advantage of students as they become more aware of the problems to be faced.

A further stimulus towards curriculum change continues to be unemployment. The (F.E.U. 1983, March) reported that employment "...increased the pressure to find a new framework through which their transition into adult society might be accomplished" because of the shortage of paid employment the framework must include elements such as "work experience", "community service", "education and training provision", which were previously given a lower priority. In September 1983 the F.E.U. reported a general agreement on social, economic and political grounds on the need for a wider range of learning opportunities.

The inter-relationships of the Government and non-Government bodies which developed was described in (Education in Science, 1984 January), see Diag 7.1 and it noted that "the links between bodies are becoming stronger and rationalisation of provision is being made."

It was suggested in Section 6 that Electronics could be taught from either an analysis (physics) approach or a systems approach, so it follows that Electronics may be adopted by either 'top-down' or 'bottom-up' curriculum developments. This Section continues to consider the role of Electronics in current initiatives vis G.C.S.E, C.P.V.E., T.V.E.I., M.E.P. etc.

7.3 MICROELECTRONICS EDUCATION PROGRAMME (M.E.P.)

In October 1978 D.E.S. wrote to the Standing Conference of Regional Advisory Committee leading to the announcement by D.E.S. of the M.E.P. programme in March 1980. The scheme was to be funded by D.E.S. at £9m over four years at March 1980 prices and administered by the Council of Educational Technology. According to D.E.S. March 1979 "The sum of the programme wil be essentially to provide a springboard for soundly based wider development throughout schools and F.E. colleges by exploiting existing skills and initiatives."

7.3.1 (McMahon and Anderson 1980, 207) wrote "Various statements made in the Governments annoucements suggest that the aim of the Programme is not to achieve implementation of new

Diagram 7·1

A.S.E 14–19 Sub-Committee ;

The Curriculum Influences—14 to 18

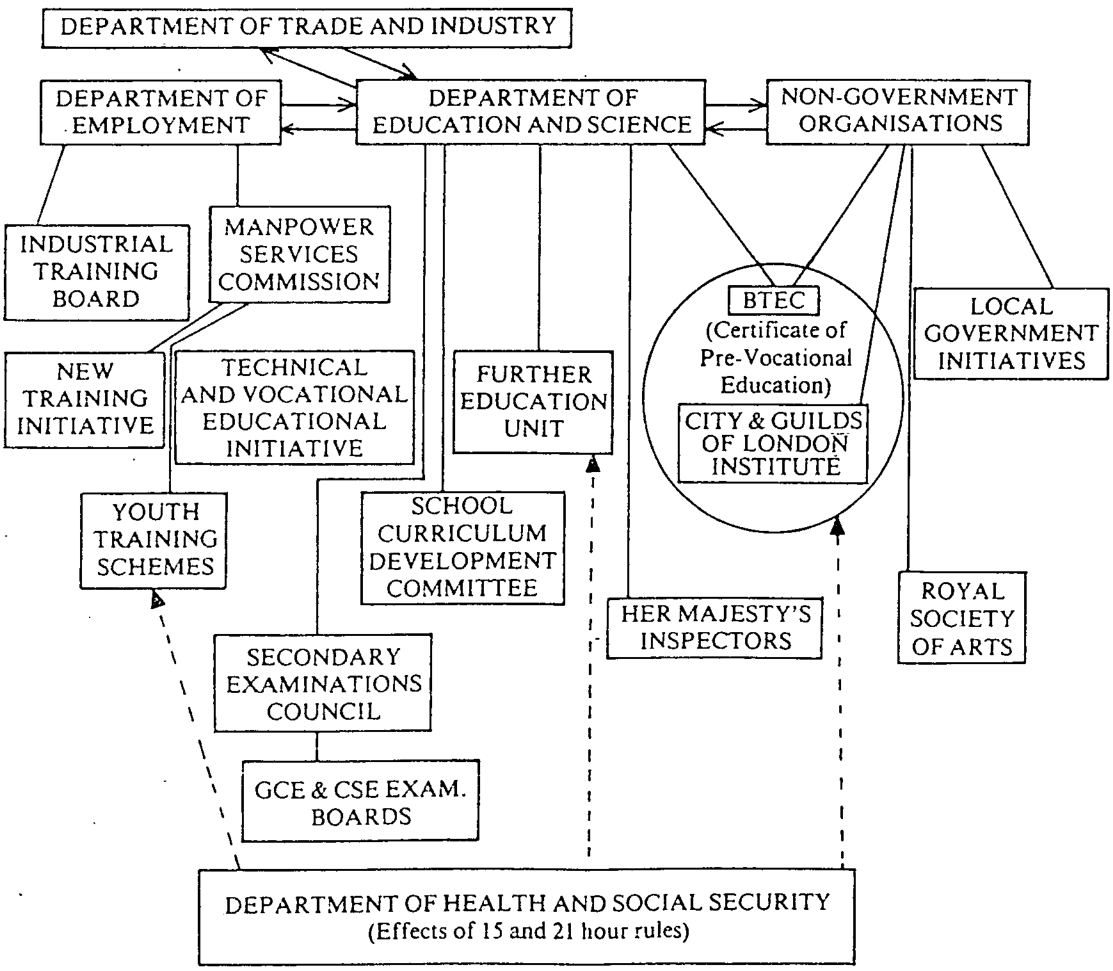


Figure 1 shows a simplified diagram of the relationships between the Government and non-Government bodies influencing the curriculum in the 14 to 18 age range. Increasingly the links between bodies are becoming stronger and rationalisation of provision is being made.

curricula and methods across all or even most schools and colleges, but instead to establish and evaluate good practise in a smaller number of institutions which can then be the basis upon which wider dissemination takes place." (McMahon and Anderson 1980, 211) advocated a planned decentralised management model as being "the most ambitious and most complex task but also the one most likely to yield the greatest rewards in the end". Four features were described:

i) to build up expertise on a broad front acting as a front line service of local use.

ii) each centre to develop area(s) of specialist knowledge and skills to complement other areas.

iii) an overall need for liason to avoid duplication.

iv) development, evaluation, transfer and dissemination networks should exist, each to be in existence for differing periods of time and with different objectives providing four simultaneous networks.

Such an analysis was consistent with contemporary theory (7.1) allowing for local involvement. However the basic pattern remains that of a series of linear R D and D models between centres (4.2.9.4).

7.3.2 In effect the M.E.P. was initiated in 1981 to end in March 1986, the Aims in the Information File Autumn 1983 were given as:

i) to promote, within the School curriculum, the study of microelectronics and its effects.

ii) to prepare children for life in a society on which devices and systems based on microelectronics are commonplace and pervasive.

iii) to help and encourage teachers to use the technology as an aid to teaching and learning.

7.3.3 In 1984, the scope of the programme was stated to cover schools and non-vocational F.E. for G.C.E. syllabuses leading to pre-vocational qualifications on the basis of certain assumptions:

i) The School curriculum would be enhanced by amending the content and approach of subjects within the curriculum and developing new topics.

ii) Microcomputer/microprocessor equipment would be usefully applied.

iii) Use would be made of the microcomputer in independent learning and information retrieval.

iv) For those with special needs new devices/systems would be used.

These assumptions were a significant change of content after the publication of the Information File Autumn 1983, insofar as it was not made clear who will amend syllabuses to 'encourage' schools to respond or who will fund the new equipment. Insofar as M.E.P. is responsible to D.E.S. then it may be assumed that either a new central policy will appear or that the failure to comply with the assumptions will provide a basis for a major rethink on the M.E.P.

7.3.4 The organisation of M.E.P. grouped the 109 L.E.A.s of England, Northern Ireland and Wales into fourteen regions of roughly similar population (approx. 3.5m) each served by a Regional Information Centre (R.I.C.) which offered 'a materials viewing advice and general teacher support service'. In addition, four Special Education Centres (S.E.M.E.R.C.s) were linked to 'demonstrate relevant equipment and provide advice relevant to children with special needs'. These regional activities comprised two-thirds of the total programme, the remaining one-third was on a national basis. Four Nation Co-ordinators were appointed to provide a R.I.C. staff liason and centrally organise INSET direction.

(R. Dunn 1984) explained that to achieve the Aims the strategy adopted by the organisation was "to operate simultaneously in three equally important interdependent areas": These areas are considered in 7.3.5 to 7.3.7.

7.3.5 Curriculum Development: including preparation of documentation, and provision of software, equipment etc. This area later included Educational Materials, and National Evaluation and Development Centres were established at Sunderland and Salford.

7.3.5.1 The M.E.P. files show that the centres did develop areas of specialist knowledge and skills broadly across the spectrum on consultation with Schools, H.E. and F.E., Publishers, Industry, B.B.C, I.E.E., etc. (Page 1985) indicated an input from firms such as British Telecom, I.B.M., S.T.C., etc. (R. Dunn 1984) commented on the L.E.A. autonomy within the programme, the educational needs and concerns. This range of features was consistent with a central pluralist policy (5.2.5.i).

7.3.5.2 Several of the curriculum initiatives related to the Microelectronics for All (M.F.A.) course. This course was "designed as a low cost practical course which introduced the principles underlying Information Technology and demonstrated the action of basic simple IT systems". A very significant 'Principle Design Criteria' was:
"Must not require specialist technical or scientific knowledge on the part of the teachers".
This criteria should be seen in the context of two statements made by the Director, R. Fothergill:

i) 1-3-83 Birmingham Conference: "So it is incumbent on us all to have a basic familiarity with the way it works. Being able to identify and deal with simple faults, change chips on a circuit board, replace sensors, make use of different problem solving strategies, these are the fundamental skills for the future."
ii) M.E.P. Conference 1984: "all children should have a basic understanding of electronics"

Fothergill continued to propose that by introducing basic principles of simple circuitry young children would gain confidence in design etc.

(Holt 1980, 17) considered that problem solving and design could be introduced only if the curriculum introduced the basic knowledge requirements and understanding on which these two concepts depended. If the teacher is not required to have a 'specialist' knowledge then unless the curriculum is modified (7.2.3.i), it is difficult to imagine the children gaining experiental learning as suggested by Fothergill. If this introductory course is to provide a foundation for future study then some of the teachers involved will require more technical and scieintific knowledge than they already have.

Several of the units developed by the M.F.A. were similar to the Unitab Alpha and E and L units which originated in the I.E.E./A.E.B. trials. The use of such units may create a "deskilling effect of the package" with a consequent "less input, less pay": (Barton et al, 1980, 16-19). Such a situation would not create a sense of ownership etc., (7.1.2) and may not be accepted by those teachers who were not concerned with the development phase.

7.3.5.3 The M.E.P. in conjunction with Salford University, G.E.C., and Ferranti developed an M.F.A. Scheme described by (John-Martin 1984, 17-18). The scheme was prepared for a fifteen hour introduction to Information Technology for the lower secondary school; consequently the emphasis of the course was on digital electronics. It was thought that new kits for practical work should be developed specifically for this course, these were subsequently placed in 17 schools in Greater Manchester and Lancashire for trials in 1983.

(Bevis 1982, 13) suggested the M.E.P. will encourage and disseminate spontaneous local development; possibly this policy contributed to the M.F.A. schemes in a small number of areas:

i) CLEAPSE (R.J.J. Orton 1982, 7-9).

This module gave the essential features required for M.F.A. at an appropriate level of detail and would fit in at 13+, third year in either a C.D.T. or Physics or Science course so all are 'exposed'. The module adopted a systems approach as it was considered the most suitable approach in the total time of twenty hours allowed for the course although CLEAPSE would probably have chosen the systems approach on the basis of the arguments offered in Section 6.

The syllabus included the: Systems concept, binary patterns and memory, decoding patterns, logic gates, analogue vs digital coding D/A and A/D conversion,programmability and feedback.

The CLEAPSE module is being tested in schools near Uxbridge; tests will include the Unilab and Philip Harris basic units, Griffin and George microprocessor, ZX81, Unilab 1 Bit etc. Even though the weakest pupils spend only fifteen hours on a basic core, this syllabus and the range of equipment involved can be expected to pose problems for "any teacher willing to learn a new discipline". The 'timely' exercise of central 'constitutional power', (7.1.12) implicit in Criteria 2 may be considered as power-coercion rather than a 'sensitive' exercise of power (7.1.2).

ii) The Havant Schools Microelectronic Programme (Bothwell 1982, 4).

The development of this module in four secondary schools was funded by D.T.I. for £65,000 on condition that this sum was matched elsewhere. In-service training involved four groups of twelve teachers for three hour sessions. Also the L.E.A. provided supply teachers to release two co-ordinaters for 20% of the time from each school.

iii) Five North London L.E.A.s (Dean 1982, 15) S.A.T.R.O. and D.T.I. co-ordinated a scheme in twenty schools, which included simple radio, tuning circuits, logic etc.

iv) Although the LAMP project is not part of the M.E.P. scheme, it is relevant at this point to consider details of a LAMP project given by (Ainley 1984, 31-38) which indicated the level of attainment involved. Ainley observed that the LAMP, Science at Work, and Open Science projects "concerned with the teaching of science to less able or less motivated senior pupils in the secondary school includes a unit on electronics." The work 'considered' the use of the transistor as an amplifier, a switch, and as a component in an astable circuit etc. Ainley found that using a systems approach the students could be introduced to flashing and noise making circuits based on the 555, then pulses were counted using a binary counter and seven segment display. Other integrated circuits such as 741, ZN414 were also used.

Ainley expressed the opinion that to avoid the subject bceoming a form of "cookery" the "skill of the teacher is of paramount importance". This view was consistent with those given in 6.2.8 and is relevant to comments made in 7.3.5.2.

Ainley also reported "considerable profit can be obtained by exploring the circuit as it works with a voltmeter". If Ainley can make this point on a LAMP project, then teachers with more able and motivated students could perhaps be expected to develop ideas even more rigorously.

7.3.5.4 As information from these various schemes is made available to all schools a close identity of purpose between the M.F.A. scheme and the S.S.C.R. Science for All is apparent; and the whole resembles a Dis-equalisation negotation (4.4.3.i).

In comparison with the central R D and D programme used in the 1960's and 1970's the M.E.P. scheme is extremely diverse in this Development phase and must undoubtedly stimulate a broad interest in Electronics.

(MacDonald and Walker 1976, 54) discussed the reasons for the 'take-off' of Geography, these may be summarised as: there were not too many facts or naive trivial explaining instead the topic was lively including concepts, patterns and processes given in relation to society. Although the M.E.P. has not built up a teacher network in the same way as the Geography project the similarity of features in the M.F.A. project for the 12-14 age group could be expected to contribute to the 'take-off' of Electronics.

In the event of a 'take-off':

i) if resources are made available to schools it can be expected that those resources will be used extensively on the 14-16+ courses.

ii) the familiarity of students with Electronics and their enjoyment will provide a firm basis for 14-16+ courses.

iii) the syllabus content and treatment at 14-16+ will alter to build on (ii) and to maintain 'novelty'. Such alteration would be in line with the comments made in 7.3.3., and could be expected to take five years (M.E.P. File Autumn 1984, 3).

Any problems in staffing the M.F.A. Science for All-Electronics Option schemes may appear trivial in comparison to staffing problems caused if there was growth in G.C.S.E. courses which include Electronics. Comment on the G.C.S.E. and Electronics INSET is made in Section 8.

7.3.5.5 The M.E.P. Information File Autumn 1983 made the suggestion that the national need to be able to "flush-out" technological talent further "underpinned and complemented" the justification for M.F.A. Fothergill pointed out that some will "move on to more specialised work" and he asked "how are we making use of the modern technology to improve experimentation to make it more like that which is, and must be, practised in modern industry?". Such comments are consistent with the concern of both Central Government and Industry, but questions of financing remain largely unanswered.

One answer was provided when the then D.O.I. in 1983 provided financial assistance to schools to purchase items related to microelectronics and microcomputers amongst which was the V.E.L.A. This Scheme excluded F.E. and thus discriminated in favour of those LE.A.s using tertiary and sixth form college provision.

7.3.6 Teacher Training

Four domains were identified by M.E.P. of which the Electronics and Control Technology domain is pertinent to this thesis.

Each domain had a National Co-ordinator appointed by an Advisory Committee which included representation from teachers, L.E.A. advisers, H.M.I., teacher trainees, commerce and industry. "Each domain is served in each Region under the guidance of a Domain Co-ordinator who is responsible for establishing the pattern of courses". (Bevis 1985) stated that the E.C.T. Regional Co-ordinator were in day to day contact with practising teachers.

M.E.P. was to provide pilot I.N.S.E.T. courses only, further provision was dependent upon the input from the L.E.A.s. The E.C.T. I.N.S.E.T. was concerned with the development of teacher's expertise necessary for them "to teach the current electronic component of the many examined and non-examined courses which include this subject" also to extend this "minimum expertise into the implications of current and potential new applications of Microelectronic Technology to all aspects of work and life." The Information File Autumn 1984 indicated that the I.N.S.E.T. scheme was extended to 'A' level Electronics Technology Practical Modules. The new I.N.S.E.T. courses will relate closely to the revised A.E.B. 'A' level Electronics syllabus and practical materials will be featured which were prepared by a working group of thirty experienced teachers, teacher trainees and advisers: (Bevis 1985,24).

M.E.P. documents stated "it is teachers who ultimately influence the content and philosophy of teaching syllabuses". This is not consistent with S.E.C. policy and top-down curriculum review and as only a few schools were represented in the M.E.P. schemes perhaps the wording should be "some teachers".

(Fothergill 1983) reported that M.E.P. had trained 40,000 teachers sufficiently for them to introduce computing and or electronics. Later in 1984 he reported encouraging participation in I.N.S.E.T. by L.E.A.s and an extension to initial training of teachers. As the scheme gets fully under way it will be interesting to see if the concept of (Fothergill 1982) of a "cascade approach" to I.N.S.E.T. will apply.

Sunderland L.E.A. moved onto the 'second phase' of activity running a course in 'Electronics for Teachers' jointly at Monkwearmouth C.F.E. and the Microelectronics Centre, which the Authority shares with M.E.P. This course was offered in connection with the T.V.E.I. scheme and the number of applicants was such that a second ten week course to commence Autumn 1985 was also fully booked. Further comment on this course is made in Section 8.

To support the I.N.S.E.T. Programme, M.E.P. developed a Distance Learning Initiative based on a previous C.S.E. course. A logic tutor and worksheets were made available and it was suggested that these materials would help to meet the need of "totally inexperienced teachers to make a start..." The realism of M.E.P. in appreciating that there is a problem of teacher release is creditable but the production of the 'Distance Learning' materials provides no 'ownership'. Such materials includes good practice from a small number of institutions which were relatively well funded and many teachers comment on the problems faced in introducing the materials into their less generously funded situations.

7.3.7 Information Dissemination

This activity arises from Curriculum Development, Teacher Training etc., and involves the circulation of literature such as the M.E.P. Information files, Electronics Systems News produced in consultation with I.E.E., the Microelectronics handbook produced in concultation with B.P. Educational Service, and liason with the B.B.C.

The R.I.C.s will keep available demonstration equipment; also a broad range of literature collations, syllabus, examination papers with details of regional activities.

7.3.8. The actions taken in these three areas of strategy, described in 7.3.5 to 7.3.7, correspond closely to those actions suggested by McMahon and Anderson, it can be anticipated that in looking to the end of the M.E.P. in March 1986 attention will be given to the advice of McMahon and Anderson: "Mechanisms for identifying, establishing and ensuring appropriate continuation funding for all dissemination centres need to be established during the Programme itself".

Perhaps a weakness in the M.E.P. scheme is the L.E.A. input, McMahon and Anderson suggested certain Regional tasks including:

i) Evaluation of the 'state of the art' in the Region;

ii) Set up a Standing Conference to identify and develop needs for microelectronics education;

iii) Conceptualise a local network;

iv) Putative (loosely structured) groups would independently or co-operatively submit development proposals.

Where funding did not allow these tasks excluded non-vocational F.E. to the extent that not even Electronic Systems News was provided to F.E.

Such exclusion of F.E. was inconsistent with (R.Dunn 1984) who advocated that M.E.P. would relate "to a wide range of educational needs and concerns in introducing microelectronics to the classroom". The input of F.E. in the 16-18 electronics examinations is such that even if F.E. is involved in National Schemes its exclusion from Regional Schemes must have affected the balance.

Many L.E.A.s quickly equated microelectronics to microcomputing; writers such as (Dean 1981) tend to give an emphasis to microcomputing. Perhaps this emphasis followed from the D.E.S. November 1980 announcement of projects which was in April 1981 interpreted by the Prime Minister, Mrs. Thatcher, as 'a microcomputer in every school'. The November statement included F.E. but in practice financing could not always embrace F.E. in the Programme or even in purchase schemes (7.3.5.5).

Whether or not F.E. was officially "by-passed" from the provisions of the scheme is difficult to determine but it is significant to note that "The major statement of M.E.P. Strategy reads: "The aim of the programme is to help schools..""

7.3.9. Conclusion

An inspection of the publication of the M.E.P. and those 'institutions' 'linked' to it show a range of activities as suggested by House. However, whether or not the products from M.E.P. are acceptable to teachers will depend on attitudes within schools as well as links with M.E.P. It was noted that there are staffing difficulties, those exacerbated by falling rolls and lack of resources may inhibit the take up of M.F.A. in schools. The link from M.E.P. may not be successful:

i) Relative to schools M.E.P. has massive and daunting resources, (4.3.5.9) and it is seen as elitist by many teachers.

ii) The 'by-pass' mechanism allows the M.E.P. to be conservative.

iii) The M.E.P. policy appears to be that it can only pioneer I.N.S.E.T., therefore no linkage to 'peers' develops.

iv) M.E.P. staff are often on limited time appointments to encourage creativity: (Miles 1975), and on secondment often from grades lower than Head of Department; they may not be seen as peers by the link within a school especially as there is limited time to develop trust.

v) There is no evidence that appointments made are of teachers who intuitively established a successful teaching strategy in electronics.

vi) There is no evidence that institutions which were sponsored to develop packages had any special skills etc., in electronics.

(v) and (vi) may not allow those outside M.E.P. to identify to the innovations etc.

7.4 Secondary Science Curriculum Review

Following the restructuring of the Schools Council the Science Curriculum Review (S.S.C.R.) was set up in 1981, the curriculum development strategy chosen being Periphery-Centre (4.2.9.4). The broad aim given by (West 1983) was to develop "..a system of science courses such that all.. whatever their abilities and career intention - receive an appropriate scientific training".

It was considered that the S.S.C.R. would co-ordinate the evolution of new science teaching strategies unifying the mechanism of "problem solving", and provide an answer to outside threats vis T.V.E.I. (Hornsby 1984).

Groups of practising teachers and others were formally formed by L.E.A.s (in England and Wales) or Education and Library Boards (in Northern Ireland). The groups selected feasible tasks based on the interests of the members, schools etc., allowing a local identity (4.3.5.6) and the tasks were submitted to both the Education Authority and the S.S.C.R. for approval. If approved resources for the development programme were provided by the Authority, the programme was supported and co-ordinated (4.2.9.4), on a regional basis by one of six full time Regional Project Leaders funded by the Review. The groups were further supported by a Central team which was responsible for overall planning, control of the development policy, production and dissemination of reports etc., and liason with external agencies. Typically the groups met once per month after school, in-service training allowed meetings as a number of days or half-days per year. Thus the model contains many of the features of Problem Solving (4.2.8.3), and allows the role of the teacher to alter (4.3.5.4), allowing a by-pass (7.1.4).

(Hargreaves 1982) criticised school centred innovation because of "the dirth of rigorous, critical, and empirically grounded accounts of particular schemes and projects". The S.S.C.R. projects are not yet completed, but a general invitation was issued, June 1984, to those who wished to particpate in the products of the Review. The invitation was accompanied by a general framework of evaluation consistent with the view of Rivlin who required agreement - "to use common measures of what is accomplished so that results can be compared": quoted by (House 1974, 228). She further observed all this requires is "strong central leadership".

The last point was developed by (Hargreaves 1982) who noted that the S.S.C.R. 'was central in origin and hardly as grass roots as it pretends'. He also observed that there is no value in teacher involvement if the teachers are excluded from other important contacts.

(Long 1983) observed that the framework of the Review excluded the possibility of three separate sciences: Biology, Chemistry and Physics, tending instead to the integration of subjects. Several of the projects under development involve Electronics (See Table 7.1), a subject described in 6.2 as providing a sound basis for the integration of activities.

A somewhat similar initiative to that of the S.S.C.R. involves the B.P./Centre for the study of Comprehensive Schools Scheme at York; within that initiative a school is developing microelectronics and computer literacy across the curriculum for the whole ability range.

Social learning theory suggests that local control is needed for maximum commitment to innovation but (Rogers and Marcus 1983) expressed concern about two dangers:

i) when there is decentralised control in subjects involving "a high degree of technical expertise" it is possible for "bad innovation to diffuse

ii) local users may not be able to appreciate and use the total information available, where technical expertise is involved a central co-ordinator could be usefully included.

These points are pertinent to the activities of the S.S.C.R. in electronics. If a local group did not appreciate their lack of expertise it is equally possible that the Regional link would not.

Electronics syllabuses are changing towards a Systems approach increasingly based on integrated circuits and the findings of the A.P.U. suggest that students should be encouraged to appreciate the circuitry of the blocks and test accordingly. Ainley, (7.2.5.3iv) provided encouragement to those who would attempt to do so across the ability range. During the review phase of the S.S.C.R. the work of local groups should be considered against this background and the similar activities within the M.F.A. project. In contrast to the relatively well funded M.E.P. supported projects the S.S.C.R. Electronics groups may reveal the reality of the situation regarding resources and their usage.

The information on resources should emerge insofar as the S.S.C.R. Review criteria suggested that cost implications should be considered. The request for such information and the concept of self evaluation (Hornsby 1984, 15) will provide for some teachers an initial experience of course validation procedures and should be a useful exercise for those contemplating running courses in Electronics using models such as the B.T.E.C. units.

7.5 Technical and Vocational Education Initiative (T.V.E.I.)

This is a scheme funded by M.S.C. at £3,000 per year for each pupil plus local funding compared with a normal L.E.A. funding of £30 per year: (Teacher 1985, 22 Feb, 4), (T.V.E.I. Review, 1984). The scheme was described as "the beach-head from which to colonise all secondary education: (Young.M. 1983, T.E.S. 4/3). At present approximately 65% of the L.E.A.s in England and Wales are included, of which 57 are currently running courses; the White Paper, 'Better Schools' indicated that the great majority of L.E.A.s would become involved.

7.5.1 The Aims of the scheme were to equip young people across the ability range with the personal skills and attitudes required for employment and to facilitate the transition from Schools to employment. This scheme was intended to encourage schools to substitute learning by practical experience for conventional academic instruction thus emphasising problem-solving.

The scheme placed an emphasis on transferrable skills and it should be sufficiently flexible to allow for students who either change their career choice or leave a school. Many authorities designed T.V.E.I. courses which had much in common with other courses so that a basic course could be extended to allow certification using C.G.L.I. General Vocational Preparation 365, C.G.L.I. Foundation Course, C.G.L.I. General Abilities Profiling System C.S.E., G.C.E. etc. syllabuses. Recent reports (T.E.S. 1985, 15 Feb) indicated that the Welsh Joint Education Committee in consultation with Clywd and Gwynedd produced a radically reformed syllabus using modules to meet the needs of T.V.E.I. This course is similar to a C.S.E. Mode 3, it includes only 20%

written tests with an overall assessment.

The T.V.E.I. scheme includes core experiences and options, and in many L.E.A.s one option is Electronics, typically in a form relating to a broad industrial sector rather than to a narrow vocation. Sunderland L.E.A. submitted an Electronics Extension which was designed to be suitable for those students who would "not reach the required standard to successfully gain any certification" and which would allow extension to C.S.E. and 'O' level Electronics. The option was allocated ½ day per week over two years; also it was considered that if Electronics was important then aspects of electronics should appear in each of the core experiences. The content of the Sunderland course was presented as a series of learning objectives so that at a later date the syllabus could be considered for use as a level 1 B.T.E.C. Unit. Such a unit could form part of a broad framework such as the B.T.E.C. Technicians Studies Course (6.3.7). The use of 60 hour level 1 units would give an improved opportunity of certification in areas of student motivation and would allow progession to further education.

In response to the (Alvey Report 1982), an F.E.V. paper by (Neale,D.F. and D.R. Wilson,1984) suggested seventeen modules involving Physics, Circuit Theory, Electronics, Computer Fundamentals etc. Of these, eleven modules were related to the syllabus contents given for electronics in Section 6. These modules were described at three levels:

i) No prior knowledge, minimum mathematical ability, could provide the basis of Y.T.S. or Awareness courses.

ii) Ability for analysis and testing eg. technician training.

iii) Ability to design eg. graduate.

The levels (i) and (ii) may be appropriate to T.V.E.I.

However, the use of B.T.E.C. units will involve schools in a form of examination in which they are not familiar. The schools would also be required to go through a validation procedure which requires the submission of details of resources vis. staff, rooms, equipment etc. This latter procedure is not unlike the administrative process being used to collect data on the T.V.E.I. Scheme within schools so that in this sense the T.V.E.I. is a sensitive strategy towards a 'big shift of attitude'.

7.5.2 The Sunderland T.V.E.I. Electronics Extension required that the Aims and Objectives of the course were taught in a context of relevance; it was recommended that 'in the home' would be suitable. The Extension was to be integrated into the total curriculum:

i) Safety and Health: use of symbols; colour perception; noise; use of chemicals; wiring code; plug testing etc.

ii) Science: transducers; instrumentation; materials used in the manufacture of components etc.

iii) Numeracy: use of symbols; analysis of data; graphical representation.

iv) Communication: report writing skills; verbal discussion; concepts of radio, TV, etc.

v) Technology: control; instrumentation; quality control.

vi) Design: printed circuit work; report presentation; wiring lay-out.

vii) Music: frequency divider-octave; filters etc.

viii) Society: effects of improved production; communication; changing patterns of employment and leisure.

On the basis of experience gained from A.E.B. 'O' level Electronics courses, it was considered that this approach and the opportunity of practical work would be acceptable to students allowing them to acquire a range in skills consistent with T.V.E.I. philosophy.

7.5.3 A significant number of schools associated with the T.V.E.I. scheme introduced courses in 1984 leading to either A.E.B. 'O' level Electronics, or the Electronics option in C.D.T., or the Electronics option in N.E.A. 'O' Phsyics. This growth of interest raises problems of I.N.S.E.T., if the electronics is to be taught so that all educational advantage is obtained. If B.T.E.C. modules are used, then administration and teaching problems in connection with resit phase tests will require consideration in the pilot schemes.

The pilot T.V.E.I. was restrained officially to a limited number of students in the programme (T.E.S. 15 March'85, p.14) eg. Durham L.E.A. submission stated 20% of the total age group. In view of the generous funding, there is concern at the problem of extending the implications of T.V.E.I. to all of the 14-16 year olds. The added suggestion that in view of the funding streaming was used to obtain success: (Teacher 22 Feb 1985, p.4) exacerbates this concern.

The T.V.E.I. has a strong central control and within the ranges of its projects the total overall strategy has many of the features given by Rubin (4.2.5). 'The dissatisfaction' (4.2.5.3.ii), being brought about by a local lack of resources, the reward being the generous funding which allows equipment to be brought into a centre for wider use. When an authority obtained resources eg. E.E.C. in addition to T.V.E.I. a major input into new subject areas was possible. Linking, (4.2.5.3.vii) is encouraged by the simultaneous work of S.S.C.R., L.A.M.P. etc., creating a constant stream of innovation under a centralised control (4.3.1.5). Such is the extent of these simultaneous projects in electronics that they may represent a deliberate policy to implement a Normative-Re-Educative strategy (4.5.2), by involving staff. For example, staff who were previously unfamiliar with the use of objectives may acquire experience through the T.V.E.I. system of records and the S.S.C.R. evaluation phase prior to the introduction of G.C.S.E. Also there can be little doubt that experience acquired via T.V.E.I. on 'Skills testing by observation in Situ' will provide teachers with a better basis for introducing G.C.S.E. than was given to F.E. staff for T.E.C. (6.3.4.ii).

(Sir Keith Joseph, March 1985) showed how important T.V.E.I. is regarded when he announced that grants would be made to promote T.V.E.I.-related developments throughout the curriculum. This money is to "be channelled to new technology, bio-technology and electronics": (T.E.S. 29th March p.13). A T.E.S. feature (T.E.S. 3rd May p.33) suggested that some radical changes and innovations were already apparent.

7.6 General Certificate of Secondary Education (G.C.S.E.)

7.6.1 This single examination will replace G.C.E.'O' level, C.S.E. and Joint 16+ examinations, the first examination will be taken in Summer 1988.

The examination will be offered by regrouped examination authorities:

i) Northern Examining Association: one G.C.E. Board: Joint Matriculation Board; four C.S.E. Boards: the Associated Lancashire Schools Examining Board, the North Regional Examinations Board, the North West Regional Examinations Board, and the Yorkshire and Humberside Regional Examinations Board.

ii) London Examining Group: one G.C.E. Board: University of London Entrance and School Examinations Council; two C.S.E. Boards: the East Anglian Examination Board, and the London Regional Examining Board.

iii) Midlands Examining Group: two G.C.E. Boards: the University of Cambridge Local Examinations Syndicate, the Oxford and Cambrdige Schools Examination Board; two C.S.E. Boards: the East Midlands Regional Examinations Board and the West Midlands Examinations Board.

iv) Southern Examining Group: three G.C.E. Boards: the Associated Examining Board, the University of Oxford Delegacy of Local Examinations and the Southern Universities Joint Boards for Schools Examinations; three C.S.E. Boards: the Southern Regional

Examinations Board, the South East Regional Examinations Board, and the South Western Examinations Board.

v) Welsh Joint Education Committee (W.J.E.C.)

vi) Northern Ireland Schools Examinations Council.

7.6.2. Of these the London Group and the W.J.E.C. released details of their proposed Electronics syllabuses in 1984. Both were broadly similar to the A.E.B. 'O' level Electronics 080 (Section 6).

The W.J.E.C. proposals included a choice of one option from four:

i) Communication Systems.

ii) Instrumentation and Control.

iii) Medical Electronics.

iv) Microcomputer and Control Systems.

These extended the content of the A.E.B. Electronics in Society section and included Control, Bioelectronic and Clinical Electronics. The latter were novel and reinforced the integration theme of Electronics.

The London proposals required each centre to be sent six design briefs in January of which the student will be given a choice of one from four. This may prove to be difficult to operate as centres rarely carry a sufficient stock of components and ordering can cause delays. Many A.E.B. centres require candidates to purchase their own components due to a lack of resources at the centre, but a compensating factor is that the student makes something of their own choice which can be taken home. The London proposal may add to the inadeqacy of resources already severe due to practical requirements.

Both the London University Examinations Board and the W.J.E.B. included an Aim referring to either 'interest and enjoyment' or 'leisure', so that either could be extended from a suitably designed T.V.E.I. Scheme. Other differences with A.E.B. 080 were minor involving specific components: thyristor, 555, F.E.T.; and circuits: monostable, bi-stable etc.

The timing of these proposals may be premature as a recent decision was to insist upon differentiated papers or differentiated questions. The consequence of this decision and the decision to use grade related criteria may lead to a situation where the syllabus content and assessment schemes are not totally compatable. Also the proposals did not include provision for 'Records of Achievement for School Leavers' etc., and if such provision is made there will be difficulty in finding teacher time for assessement in view of the total syllabus content. Other 16+ proposals included the use of Distinction and Merit awards described by some as being divisive and not able to accomodate interdisciplinary subjects. If the latter criticism was valid then the case for including Electronics could be strengthened as that subject itself integrates several areas of the curriculum. However, the suggestion that only two sciences should be studied may reinforce the stating of the traditional science subjects to the detriment of Electronics unless Electronics was placed in the 'Technology' blank.

TABLE 7.1

GROUP CODE	REGION	GROUP CATEGORY	INDUSTRIAL APPLICATION OF ELECTRONICS
WALSA-02	MI	C	
KENT-04	AN	C	Applied Physics 14 - 16
HEREF-06	MI	C	Microelectronics
ESUSS-01	AN		Mechanics and Electronics Measurement
WIRRA-01	NW	C	Microelectronics application for All
NEWCA-05	NE	A	An Introduction to Electronics and Microelectronics
DURHA-08	NE	B	An Introduction to Micro-Electronic Systems
IOW-02	SO	B	Electronics for the Middle Years
HAMPS-05	SO	B	3rd Year Electronic Module
WSUSS-01	AN	B	Computer Application in Technology*
SEFOR-01	AN	A	Mechanics and Electronic Measurement
CHESH-04	NW	C	Technology through electricity, electronics and microelectronics for secondary pupils

* Involves digital electronics

7.6.3 It is not yet clear whether centres will be allowed to link to the 'vestige' of a Board or be encouraged by L.E.A.s to use one nominated Board; as committee representation will be local there is a danger of the latter decision being taken by L.E.A.s without full consultation with the staff concerned. An advantage of using a nominated Board is that a common entry provides a simpler administration; a disadvantage is that additional resources may be need if the change of Board involved a change of syllabus content. Further comment is made at the end of this section.

Table 7.2 indicates the potential strength of each Examining Body if restricted entry was used.

Table 7.2 APPROXIMATE TOTALS FOR G.C.S.E./G.C.E. ELECTRONICS EXAMINATIONS AT 16+, 17+, 18+.

	NUMBER OF ENTRANTS 1984 EXAMINATIONS			
GROUP	G.C.S.E.	A.O.+ C.E.E	A.E.B.658	A.E.B. 801
MIDLANDS	2165	420	139	106
SOUTHERN	3238	744+	282	109
LONDON and EAST ANGLIAN	3153	713+	122	111
NORTHERN	1873+	539	100	55
N.IRELAND	153+	36	60	0
WALES	~350	27	50	11

One problem will be related to economics as externally moderated project work has a minimum cost level at approximately 1,000, above that level duplication of senior moderators etc., prevents the minimum cost level being repeated. As previous C.S.E. entries will now enter the pool being moderated by an essentially G.C.E. procedure costings, the balance of profitable examinations and the un-profitable examinations offered as a service will need to be considered. The approximations in Table 7.2 indicate that at 16+ the Northern Ireland S.C. will not be economically viable and more unreliable than other groups in terms of staistical control. Both the Northern Ireland S.C. and the Welsh J.E.B. have a very low potential pool for a 17+ examination. At 18+ 'A' level the present G.C.E Boards will continue to offer examination otherwise only the Southern Group looks healthy in terms of Electronics Systems, and no single region has a viable pool at the Endorsement level. Although Boards may be expected to allow free entry to their examinations, it can be anticipated that in the immediate future the Boards will reach an 'understanding' so that not too many subjects are uneconomic. The Southern Group contains the A.E.B. and could expect support from centres in London, the new Cambridge 'A' level Electronics may expect support from the Midlands and Northern Groups. In view of social and economic factors, it would be unfortunate if strong regional influences emerged.

i) The 'interaction' of examiners, moderators etc., would be restricted; the predisposition of staff to innovations would be adversely affected (4.3.5.3).

ii) L.E.A.'s would gain a dominant authority and could control syllabus innovation for political and economic reasons; feedback and adopter behaviour would become regionalised (4.2.8.2.), and less effective.

iii) Those L.E.A.'s with resources would be able to offer a more 'modern' examination, which was more acceptable as an entry qualifications etc., thus giving a regional bias to student advantage.

7.7 Certificate of Prevocational Education (C.P.V.E.)

B.T.E.C. and C.G.L.I. established the Joint Board for Prevocational Education (J.B.P.V.E.) in May 1983 and in May 1984 details were circulated of a curriculum framework for a one year full time programme. This course was designed to replace the C.G.L.I. Foundation and 365 courses, B.T.E.C. General Awards, R.S.A. Vocational Preparation Scheme and C.E.E., and the course was described as "the long discussed '17+' qualification": (Job 1984). However, (Kirkman 1985) reported that the Oxford and Cambridge Board were to continue C.E.E. and N.E.A. was to introduce G.C.S.E. 17+, a not unexpected move in view of the desire of the Boards to maintain their status. Most C.S.E. Boards are expected to meet five of the G.C.E. Boards in April or May to discuss this further: (Teacher Vol. 41 No.27, p.4). Recent suggestions that B.T.E.C. and R.S.A. might continue to offer their examinations as an alternative to C.P.V.E. may represent a negotiating stance relative to the G.C.E. Boards otherwise the B.T.E.C. proposals will "detract from the scheme as originally envisaged": (McArthur 1985, 17).

This course continues the theme of T.V.E.I. being a unified course containing a core, vocational and additional studies with the primary aim "to make the transition from schools by providing opportunities to acquire the skills; expertise; attitudes; knowledge; personal and social competences needed for adult life": (C.G.L.I. Broadsheet No.102 Feb 1985 p.4). 700 - 900 hours were required on the course of which not less than 75% was core plus vocational with 15 days work experience. On the latter aspect, the (N.A.T.F.H.E. Journal Feb 1985) noted the "J.B.P.V.E. is sanguine about finding work placements in spite of doubts expressed by employers and others".

The aims of the course included that it should be individually relevant, practical and allow progression with additional studies to G.C.S.E. for better students. In achieving these aims, the course must be institutionally, administratively and financially viable.

The core contains ten areas all of which must be experienced, of those areas several could be integrated via Electronics as noted for T.V.E.I. (7.4), vis Science and Technology; Communication; Industrial, Social and Economic Studies; Information Technology; Decision Making and Adaptability; Practical Skills; and Numeracy. Electronics offered with a project would give a broad vocational aspect with individual relevance. Such an approach with additional studies would allow the enhancement of the course to G.C.S.E. for the motivated students. There is already evidence of the growing popularity of O and AO G.C.E. Electronics examinations as a 17+ examination. As noted with T.V.E.I., the use of suitable modules may also facilitate progression, such modules could also assist if the C.P.V.E. was to extend to part-time students and to link to Y.T.S., Y.T.P. programmes.

Four Vocational Modules are required in a course being selected from five main categories, each category being divided into clusters "based on a grouping of roles found in occupational and non-occupational activities": (C.P.V.E. Framework 1985). The Vocational Modules are introduced in three stages: Introductory, Exploratory, Preparatory. Electronics could be introduced in two of these clusters:

i) Category 2 Technical Services
Clusters; Information Technology and Micro-electronics Systems.
Service Engineering.

ii) Category 3 Production
Clusters; Manufacture.
Craft based activities.

The various initiatives such as M.F.A. and curriculum development within S.S.C.R. show that Electronics can provide the "required experiences" leading to the "learning outcomes" required by C.P.V.E. It would be unfortunate if the wording "Microelectronics" became firmly equated with Microcomputer and keyboard skills. The level of entrants may be gauged from the

D.E.S. statements that students with less than four 'O' levels will not be regarded as being vocationally committed and therefore suited to C.P.V.E. (Turner 1985). Such students may enjoy using a microcomputer and office equipment, but the significance of Electronics should not be overlooked. C.P.V.E. in their handbook do give equal emphasis to Information Technology and Microelectronics during 'Theory and Practise' however in the Project Module it is significant that the only hands-on use of equipment suggestion is: "Design and install a security system including a variety of detection and alarm devices."

This type of Project can motivate students as noted by teachers of A.E.B. Electronics and allows the teacher to relate the programme as a whole.

There is concern that the time schedule of the C.P.V.E. programme may not allow links to be established across the educational sectors to gain access to resources and expertise. The form of syllabus, assessment, and subject content may require more attention to be given to I.N.S.E.T. if integration and progression of activities is to be achieved at student level rather than on paper. The C.P.V.E. does offer an opportunity to rationalise the 'non-academic' route for education and it can be anticipated that Electronics could provide a viable motivating interest in technology for many students so that C.P.V.E. does not become a "school Y.T.S. Certificate for the students less bright": (Edwards 1984, 116-117).

7.8 Other Initiatives

7.8.1 Although not chosen as an official C.P.V.E. pilot scheme the Southern Regional Examination Board developed a "Course of Pre-Vocational Study at 17+". This course included Electronics as an option in the form of three linked modules with a strong practical bias; if required the modules could be studied individually: Electronics, Electronic Systems; An Extended Practical, Investigational, or Work Experience Unit.

These units were similar to the AO syllabus eg J.M.B. with an emphasis towards Analogue-Radio receiver rather than Digital Telephone and Microprocessor. The units could either be extended to AO or by adding an Automation and Control Module to A level. An alternative theme of study could include units such as Human Communications, and Technology, both of which usefully integrate into an Electronics System approach.

7.8.2 Y.T.S. courses are required to include transferrable skills which could be acquired through the inclusion of Electronics in the curriculum. Some centres include Electronics using C.G.L.I. and B.T.E.C. modules but in practice Electronics tends to be regarded as too vocational. This view reflects the stereotyped teaching approach too often used without regard for the broader integrating features available. If an 'employer-led' Y.T.S. developed which was linked to industry then it is probable that more students may be directed towards an improved Electronics module within that course.

7.8.3 I.T.E.C. centres provide courses in Electronics, however such courses do not normally lead to certification. In recent years I.T.E.C. activities included the provision of short evening courses which were initially competitive with F.E. but which in the longer term should stimulate interest to the benefit of F.E.

7.8.4 Open Learning initiatives are being considered in various forms, at present the Open Learning Directory only includes T.E.C. Level II Electronics Course Gq4 p.182. The associated practical presents several logistic problems which may be overcome by the use of simulation programmes, see (Sparkes 1985) and (Ogbourne and Wong 1984).

7.9 Conclusion

Several current initiatives in Education are towards a 'new curriculum' in secondary education which will include a broad vocational element. Whereas the curriculum was traditionally based on the conceptual structure of each separate subject the contributory subjects are now subordinate to a unifying concept or theme. The form is suggestive of a '..revamped system of education...": (Salter and Tapper 1981, 34).

In total, the initiatives represent a major move from Central Government which may alter the relative influence of L.E.A.'s on curriculum control. Concern was expressed by the Ass. Metropolitan Authorities: (Passmore and Lodge 1985) over increased central control, and the pressure by L.E.A.'s to control entry into the new G.C.S.E. examinations may be a sign of resistance.

Separately the initiatives appear to represent feasibility studies which if considered successful will point the way to future development. As Electronics appears in several of the schemes it may be anticipated:

i) A consensus of opinion will be reached on where and how Electronics should be included in the curriculm.

ii) Material and I.N.S.E.T. resources will be made available using resources from traditional subjects which are no longer so dominant in the curriculum.

iii) The interest in Electronics will continue to grow.

SECTION 8. THE PROVISION AND USE OF RESOURCES

"...because of the extreme youth of people in the industry. They learn what should be temporary phases in the industry, assume it was always thus and will always be thus."

CATT,I. (1985, Vol. 89, No. 1566, p.54)

This section describes the justification offered for the alternative positions (for Electronics) within the curriculum and suggests a hybrid role may evolve.

Also it is suggested that as subject growth occurs staff will require certain material resources, also advice on the significance of this resource provision in terms of safety, scope of teaching etc. It is probable that 'interested' teachers themselves given the opportunity can acquire the necessary basic skills required by the theory content of the examination syllabus and use of equipment.

I.N.S.E.T. should provide assistance for teachers in other directions, such as the scope available for the integration of topics across the curriculum, the background needed for project work, and an appreciation of how the syllabus content is changing.

Comment is made on problems encountered with resources. Suggestions are made on integration and project work.

8.1 A PLACE FOR ELECTRONICS IN THE CURRICULUM

(Pilliner 1983, 149) suggested three alternative places for Electronics in the syllabus: separate, in Physics and in C.D.T.

8.1.1 In Physics

8.1.1.1 Pilliner recommended that Electronics should not be linked with Physics. He described Physics as the "search for experimental evaluation of the unifying concepts of the physical world" and he considered that the skills of Physics "analysis" and "explanation" "..are not used for electronics at this level." Pilliner wrote that "...there should be greater emphasis on the application of physics and integration with Sciences. There seems little doubt that the nature of school physics will change in the next few years." Changes in the 'A' level physics syllabus were commented on in 6.6; and (Dorey 1983, 31) noted a "...rapid change in the context and teaching methods in 'A' level Physics" also noted were the associated requirements of Nuffield 'A' level Physics and A.E.B. 'A' level Electronics Systems for physical resources and teaching skills.

Writers such as (Summers 1983, 201-202) thought that there was an overlap between electronics and physics, which provided the best answer to staffing especially in view of the overcrowded time-table. Summers argued for a wider inclusion of Electronics in physics to provide a source of maturation, later (Summers 1985, 55-61) proposed a co-ordinated 11-18 approach to the issue. (Stephenson 1980) thought there was a danger of boosting physics with a 'gloss of electronics'. The value of the overlap was questioned by (Gosden 1984, 15) who suggested that if physics graduates were required to teach an altered subject: "There may be a particular problem for physicists who have a background restricted to physics and mathematics so far as integrated science is concerned." Electronics requires the integration of a range of activities (6.2), and its teaching at 'O' and 'A' level requires a different teacher approach to that traditionally used in Physics although the work of (Pell 1984, 365) suggested that seven type of physics teacher did exist rather than a single type.

8.1.1.2 The A.S.E. recommended that Science Departments should be involved with microelectronics giving in Section B7 the following reasons:-

i) Introductory electronics is an extension of electrical circuits which form an important part of sciences courses;

ii) A practical study of electronics and microelectronics uses concepts from other branches of science teaching;

iii) Electronic devices can assist science teaching at least as much as in other subject areas;

iv) The application of scientific principles and of micro-electronics within industry can often be discussed in the same context;

v) Those seeking a career in electronics and computers often need science subjects as entry qualifications;

vi) Science teachers educated in recent years are more likely than other teachers to have had contact with the new technology.

The same report also advises scientists to become actively involved in the appraisal of microelectronics within the whole curriculum.

Significantly (i) was suggestive of a Components approach rather than the use of systems and it may not realise the potential of Electronics in the syllabus. Reason (iii) was given earlier by (Brander 1976, 665) who suggested that if the physics syllabus was split on the grounds of overcrowding the need to understand instruments may be missed by physicists and therefore enough Electronics should be taught in Physics.

In general the reasons could apply equally well to Engineering and C.D.T. departments and they do not afford a convincing case. Indeed it is very dubious whether reason (vi) will apply to many teachers due to the attraction of industrial opportunities for anyone qualified in Electronics. (Wellington 1984) reported that very few teachers were in teacher training for Computer Science and it is probable that the same applies to Electronics.

8.1.1.3 The view of the J.M.B. expressed by (Gough 1983, 4) was that the syllabus content of 'A' level Physics could not be reduced to accomodate Electronics, also that the systems approach of Electronics was nearer to Mathematical logic and was not in common with the traditional approach of physics. The J.M.B. considered that Electronics should be outside Physics to accommodate the needs of Biologists and Chemists thus an AO Electronics syllabus was developed. (Akrill 1983, 153) expressed concern with the overlap between this syllabus and Phsyics but in reply (Gough 1983, 153-154) stated that in view of other benefits the amount of overlap was not significant.

The AO Electronics syllabuses often indicate that a teaching sequence commences with devices and as such the AO syllabuses are closer to the physics tradition than 'systems' courses. However, the use of devices rather than 'black-boxes' also extends to pre 16+ study, (Brimicombe 1984, 26) described the use of breadboard observing that "working with real electronics components was adding an extra dimension to pupils electronics education". Without this experience he considered that students could miss the point of related theory, a similar view emerges in 6.1. Brimicombe suggested that the use of components introduced students to problems hidden in 'black-boxes'.

i) the use of Not gates with D flip-flop to get a change on the rising edge as in the text-book whereas catalogues list rising edge devices.

ii) the use of decoupling capacitors to soak up stray pulses in the supply rail of sequential systems.

Similarly (Ellse 1984) expressed the feeling that "the study of a single active device such as the bipolar transistor provides a firm background..." For 'A' level studies he described an approach similar to that used during O.N.C. Electric Physics practicals twenty years ago and extended by (Cuthbert 1976) to a design situation but now considered by many a little out-dated.

8.1.1.4 Writers such as (Bevis 1983) described the educational significance of advances in digital technology especially in terms of data communication and processing and it was shown in Section 6 that syllabus content was changing towards digital. However other writers such as (Simpson 1984) commented on the relative stagnation of analogue electronics a subject area significant in everyday life in the form of radio, tape recorder, TV etc. This subject area involves problems not found with digital electronics such as spurious responses, distortion, instability, and signal to noise ratio.

Thus it would appear that at both 'O' and 'A' level a compromise will be established between the Systems and Components approaches using both digital and analogue devices, so that any interested Physics teacher should be able to extend their teaching activities into Electronics. The growth described in Section 6 appears to support this view.

8.1.2 In C.D.T.

8.1.2.1 (Mead 1983) strongly reputed the claims of the Science Department to a monopoly of the newer technological subjects such as Electronics, Electronic Systems and Control technology. He considered that technology departments should also be involved with microelectronics being given access to materials and training. Such an approach would allow technology to capitalise on recent advancements at a time when there is a call for technology in some form, to be on all time tables until the age of 16: (T.E.S. 15-2-84) Also an approach could offer many of the reasons given in support of putting Microelectronics in the Science Department. However, the Oxford Educational Research Group reported a shortage of suitable teachers and (Rolls 1985, 433) reported difficulties in recruiting both engineers in terms of the numbers qualifying and science in terms of industrial salaries.

8.1.3 In many schools and C.F.E.s Electronics is linked to Physics because of the common use of equipment, if equipment is purchased with the needs of both Physics and Electronics in mind then both gain in terms of the range of equipment obtained and the experience gained with it. However, the same staff may not be suitable for both subjects as noted earlier.

Those staff who are involved with Electronics need to consider a servicing role involving instrumentation in Science, control in C.D.T./Engineering, and basic electronics in Information Technology etc. Such a role may then evolve into an area of common interest: Information Technology Education as described by (Chapman 1983, 6).

This last option is economic and attractive but should not disguise the problems of persuading physics teachers to adopt a different teaching style with Electronics and of attracting non-physics teachers who have particular aptitudes into a 'team' attached to Physics.

Recent letters to T.E.S. (10th May, p.18), prompted by a letter by (Chapman, T.E.S. 26th April), indicate that the debate on where/how electronics is to appear in the syllabus is still a long way from being resolved.

8.2 TEACHERS PROBLEMS

Conversations with teachers involved with the A.E.B. 'O' level Electronics and on C.D.T. modules indicate that the project work especially causes problems:

i) the range of projects in a class and the consequent range of problems in construction and testing, highlights inadequate equipment resources.

ii) many of the problems are outside of the scope of conventional teacher experience, very often support facilities such as reference books are either not available or the teacher does not have time to read up.

iii) there is widespread uncertainty over the best teaching approach so that basic conepts and skills can be introduced before the construction phase of the project starts. The skills required are both manual and observational.

iv) during a project many issues arise which have an immediate relevance to general theory and broader issues of application. Unless the class are given sufficient time in a laboratory these points can not be followed up.

Critics of project work would suggest that both those problems and that of costs could be avoided if the project was omitted. However, this would detract from the potential of the course especially in view of the H.M.I. paper 'The Curriculum from 5 to

16'. The paper calls for an emphasis on 'real problems', student involvement 'at all stages of technological design', students exploration of 'ideas in their own words', 'curriculum areas should complement and reinforce each other' etc. The paper groups skills into eight categories: communications, problem-solving, observation, physical, study, creative and imaginative, personal and social, and numerial. The project can enbrace many of these features as described in Section 6, rather than be omitted teachers should be assisted with the facilities required for project work.

Assistance is required in the form of advice or equipment, literature, and teaching style. I.N.S.E.T. should build on teacher interest, and providing materials etc., in advance, then concentrate on problems mentioned during a suitably structured course.

8.3 ASPECTS OF SAFETY

Safety is an integral part of Electronics teaching and should be included where relevant throughout the course. The inherent danger of electricity and the use of protection systems must be made clear.

8.3.1 Various authors such as (Strother 1977, 315) gave details from a biological perspective of the effects of macro- and micro-stock. Typically at 120v ac dry skin with a total resistance of 100k n gives 1.2mA; this is painful but stunted through the body tissue does not affect the heart. However, if either (i) the contact reistance is lowered by wetting or puncturing the skin, or (ii) the voltage is raised, then at about 160mA death occurs due to fibrillation of the heart. The Welsh G.C.S.E. includes an option on Medical Electronics, and students studying such a course should appreciate the special problems involved with internal electrodes. The erroneous advances made in medical practice in consequence of the improved electronics devices were unofficially linked in U.S.A., with the accidental electrocution of 1200 patients per year (Strother 1977, 315). (Lacey 1982, 16) also refered to such hospital deaths.

8.3.2 Protection systems include Earth Leaking Circuit Breakers (E.L.C.B.s) (See Appendix).
The E.L.C.B.s do not:

i) operate due to overload, overload protection must be ensured with the use of fuses.

ii) protect live to neutral faults.

iii) limit the fault current during the time taken for the device to trip typically 30ms. (40ms at 240mA).

Such devices are usually fitted in laboratories and are recommended for use with portable equipment out-doors. A.E.B. made a specific recommendation (080 Notes for guidance 4.2) that E.L.C.B. protection should be provided when teaching Electronics. The devices should be regularly tested not only by using the 'push-to-test' button but also to establish that the voltage, current and sensitivity ratings are correct. The check list given by (A.S.E. Laboratory Safeguards Committee 1983) omits the latter tests.

If several outlets are used from a single E.L.C.B., then students should be advised of this fact so that if an E.L.C.B. trips they will not alter potentiometer settings etc., possibly causing their circuit to fail when the supply is restored.

8.3.3 Another safety precaution is the use of transformers, (See Appendix).

The (A.E.B. 080 Notes for Guidance, 4.2) required that all mains equipment should be earthed and have an isolating transformer; the Addendum was more specific (see Appendix). It would seem reasonable to require that all projects which use mains are checked with an earth bond tester and at 500V ac with a commercial tester and found to be satisfactory before being taken home. Careful consideration should be given not only to the rating of the fuse but also its type ie. fast-blow or slow-blow depending upon whether there are surge currents. Indeed the action and purpose of the fuse can be usefully considered at this stage to avoid the misconception that a fuse protects an appliance from damage.

This misconception caused the Electricity Council to make a special reference to the fuse in its Understanding Electricity Programme: (Q.I.P. 1984).

8.3.4 To re-inforce the concept of safety and good working practise students using low voltage supplies should be encouraged to use power supplies which include a provision for present voltage and current trip eg. IRWIN EJ 373.3, when first testing their circuits. Also in line with the A.E.B. 080 Addendum it would be preferable if the power supply units being used included a mains switch and indicator. A range of laboratory power supply units, both single and dual rail, are now available with much improved line and load regulation compared with a few years ago, but not all include a switch etc. There are also many recommended stabilised circuits based on readily available I.C.s which compare favourably in cost with commercial units eg. Edu Elequip TL50 and Unilab 5v but complete evidence of 'safety practise' is not always clear on the modules.

It is also relevant when using mains with projects to introduce students to the danger of high resistance in the earth connection of a main socket. The (A.S.E. Laboratory Safeguards Committee 1983) recommended the use of a Checkerplug. (Ellse 1977, 821) criticised this test and suggested the use of the circuit shown in Diagram 8.1.

i) connect across the line-earth. If the circuit is protected by an E.L.C.B. then this should trip, if the circuit is not so protected the light bulb should light at full brightness and the voltage shown should drop by not mroe than 2v.

ii) repeat with the line-neutral to test for adequate continuity in the neutral conductor.

8.3.5 Teaching staff need to be aware of hazards other than electrical not all of which are given due attention:

Diagram 8·1 : Test circuit for Mains Socket (8·3·3)

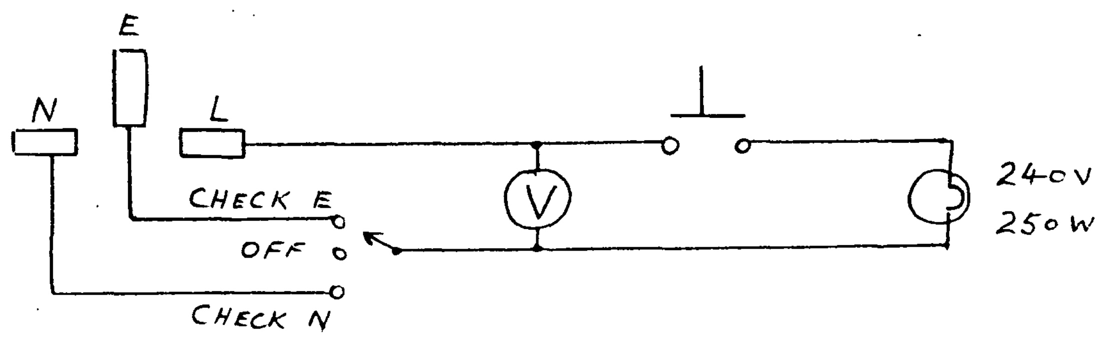
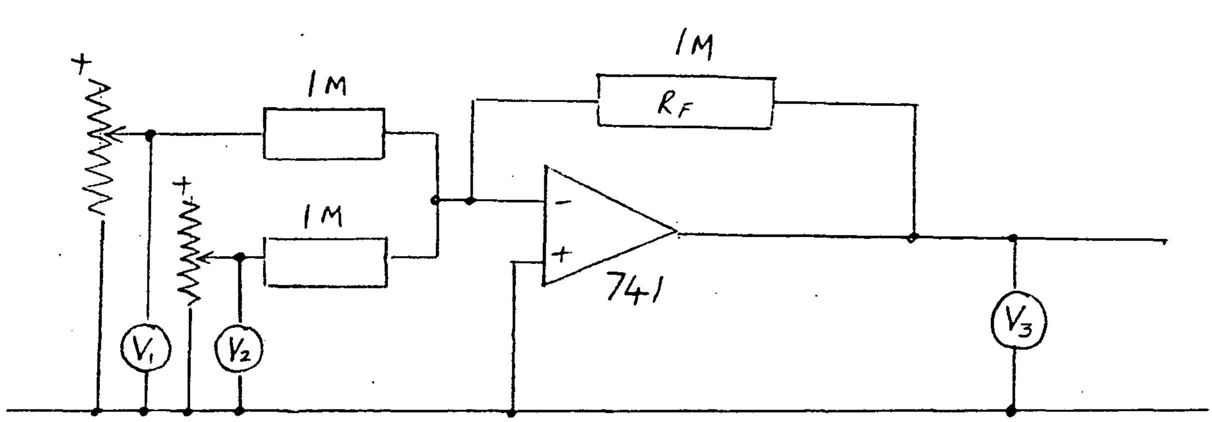


Diagram 8·2 : Summing Op-Amp (8·5·1)



i) Although attention is given to the risk of burns from soldering irons and of the electrical safety, indeed low voltage irons are often specified eg. W.J.E.C. Electronics syllabus, very little data is available on the health risk of flux. Hard soldering uses a flux which commonly contains a resin called colophony (or rosin). This is a skin irritant and it can cause sensitization of skin and lungs, evidenced as asthma. Most symptoms get better once sufferers are not exposed, but once a person is sensitized exposure to levels of fume below the 'thresh-hold' level will set off an asthma attack.

This danger resulted in solder flux being placed on the list of prescribed agents for industrial asthma, (D.H.S.S. Leaflet NI 237/Mar 82 Occupational Asthma), and it requires that sensible precautions should be taken. The level of exposure will be brief during practical/project work but for those naturally at risk the lighting level should be good so that students do not need to lean over the work, also soldering should be carried out in a ventilated area.

ii) Increasingly students make their own printed circuit boards, p.c.b.'s. Precautions should be taken to avoid spillage of etchant and solvents, protective clothing including goggles, should be used when etching and fumes should be extracted.

iii) A consultative document was published in 1984 on Health Protection Against the Dangers of Extra Low Frequency Radio-frequency and Microwave Radiation. This document indicated that hand held radio transmitters, intruder alarms and proximity devices "may be regarded as harmless" BUT they should be designed so that they can not deliver greater than 4 watts per kilogram body weight to the eye for long periods.

iv) Isolated capacitors will hold high voltages for long periods of time; similarly in voltage doubler circuits capacitors will hold charge at a high voltage level from an innocuous supply voltage. In all such cases, capacitors should be discharged by shorting them out before making contact.

v) Colour blindness can result in a mistaken identity of a colour code, (Vokes 1980, 48) estimated that "Over two million men in Britain alone may be at risk .... in the electronics field these errors in colour identification are most noticeable." She indicated that 'dichromats' could make errors of 20% in handling resistors. (Kavanagh 1978, 369) in a letter suggested that the present colour coding for Electrical wiring was chosen to avoid such defects, appearing for the colour blind as dark, light, and striped for the live, neutral and earth wires respectively.

The Electronics syllabus for the Sunderland L.E.A., T.V.E.I., submission included colour identification insofar as it introduced aspects of Safety and Career Aptitude.

vi) (Tully 1983) suggested that video display units, (v.d.u.s) could cause "fatigue" problems. He indicated that the room lighting requirements for the v.d.u. may not be compatible with the requirements for other tasks within the same room; recommednations for lighting, temperature, humidity etc., were made. Although it is improbable that many problems will result from the relatively short times of v.d.u. usage in a laboratory, nevertheless if good working practise is to be encouraged proper

working conditions should be provided.
As many students have home computers, it is important that bad habits are discouraged in the laboratory especially as there may be long term health risks not yet fully appreciated.

The N.U.T. recently refered to an A.P.E.X. report and to the need to monitor professional and industrial illnesses caused by use of microcomputers eg. video screens: (Teacher 1985).

8.4 LABORATORY EQUIPMENT: METERS, C.R.O.s AND MATCHING

Space does not allow a comprehensive survey of the range of laboratory equipment available. New equipment continually appears, usually at prices which represent a reduction in real terms and with improved facilities. The rate at which this equipment is being assimilated into teaching practise is reflected in the changing recommendation of (Bevis 1978), (Grace 1981) and (W.J.E.C. 1984 Systems Electronics).

(Borcherds 1984, 125-127) wrote: "Rapid and continuing developments in electronics make it necessary to revise continually the teaching of electronics and to replace obsalescent laboratory exercises." As examples of this change the use of meters and the C.R.O. will be considered; in this context some aspects of matching are also considered.

8.4.1 When Griffin and George introduced Mektronics kits for the teaching of transistors the range of meters available was not suitable for such simple experiments as common emitter amplifier characteristics. When meter ranges were altered, the 'loading-error' was significant in the total circuit and a discontinuous stepped graph was obtained rather than a smooth curve. Digital meters which became available in the 1950's became smaller and more effective due to improvements in manufacture so that by 1975 meters such as the Fluke 800A were available at below £100. Now it is possible to purchase a cheap digital multimeter so that a student may no longer experience 'loading-errors'.

At present a student may be provided with either an analogue, 'D'Arsonval, moving coil meter at approximately £10 or a digital multimeter, at approximately £30 eg HUNG CHANG HC6100. Observation of students and teachers show a clear preference for the digital mutlimeter especially if it is autoranging. Students dislike the need to choose the appropriate scale on an analogue meter which has several different scales. Accordingly a simple experiment may be presented at 'O' level:

An experiment such as the Summary Op-Amp requires the use of three meters as shown in Diagram 8.2, see p. 205.

If both V1 and V2 are digital meters reading voltages such as 100, 200 ..... 1000mV then experience shows that an analogue meter can be used at V3 and the relatively weak students will choose the correct scale and gain confidence. Also given that $\text{Gain} = \frac{RF}{R1N}$ students can perform simple calculations and choose the correct scale. Students can also be led to observe that the analogue meter damps out the fluctuations. If such an experiment is proposed then it is suggested that either some of the power supply units should provide variable voltage eg. IRWIN EF 392, or they should link to a suitable boxed potentiometer eg. UNILAB dual potentiometer.

To provide students with an experience of 'loading-errors', it is interesting to provide them with a 'black-box' containing a diode, analogue meters and the necessary apparatus with the aim of testing their equipment to determine whether or not it will give the characteristic in a given text. When an incorrect graph is obtained with digital meters, the students can be led to realise that measuring instruments require energy to operate them. Also the students can be introduced to a comparison of the relative costing of meters.
Both experiments illusrate that the revision of teaching methods to include to previous practises can lead to learning experiences often excluded by modern apparatus: matching; and mathematical scale conversion;

8.4.2 As an 'O' level course develops the concept of matching can be re-introduced especially through projects. Students and teachers often report failure of their circuit whereas a mismatch has occured.

i) for maximum power transfer, as when driving a loudspeaker from an ouput stage of an amplifier, the output impedance of the driving stage must equal the input of the stage being driven.
ii) for maximum voltage transfer as when measuring a voltage in a circuit or when a pick up cartridge or other voltage generating transducer is used, the output resistance of the stage

producing the voltage must be less than one tenth the input resistance of the next stage.

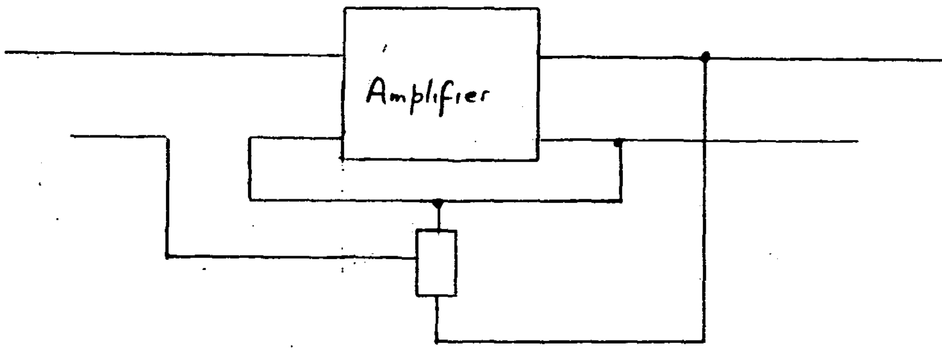
iii) for maximum current transfer the previous conditions are reversed

Several syllabuses refer to the use of the Darlington pair, emitter-follower, bootstrapping, and transformer for matching. Insofar as widespread use is made of the Op-Amp perhaps use could be made of the Op-Amp for matching: (Bishop 1974, 64), Diagram 8.3.

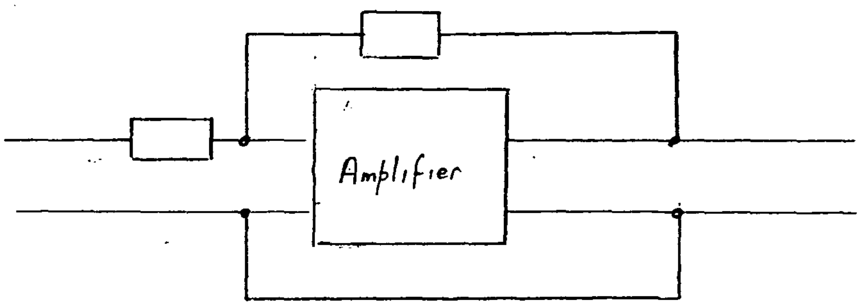
Most examination questions involve the Shunt-Voltage mode; the A.E.B. 'A' level Electronic Systems 1977 Paper 2 Question 17, involved the Series-Voltage mode, but only as a problem on feedback.

It is relevant at this point to note that within the syllabus the transistor is used to provide simple calculations, an example of a fundamental component, and as a lead in to a simple logic gate. In terms of the latter applications, the digital content of the syllabus dictates the nature of the analogue content. From an analogue point of view, it may be preferable to omit the transistor in some cases and use the Op-Amp. The Op-Amp has a significant advantage in that it switches to Vsat rather than involve the variable value of Vbe of a transistor which can present some teachers with difficulty in clearly identifying logic 1 and 0 states.

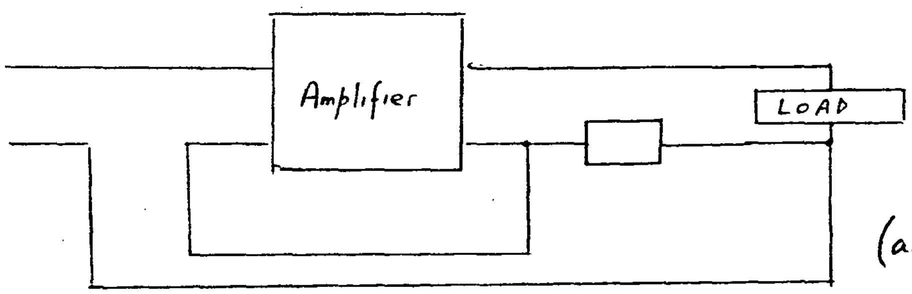
Diagram 8.3 : Op-Amp feedback configurations (8.5.2)



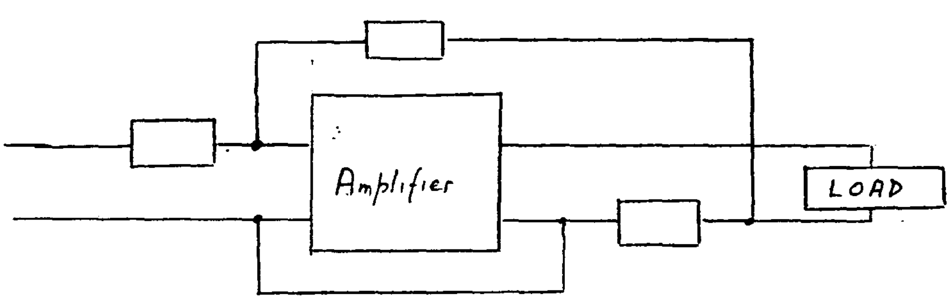
SERIES - VOLTAGE (alt. voltage-voltage)



SHUNT - VOLTAGE (alt. current-voltage)



SERIES - CURRENT (alt. voltage-current)



SHUNT - CURRENT (alt current-current)

Diagram 8.3 Cont

TYPE OF FEEDBACK	Impedance change	
	INPUT	OUTPUT
Series-Voltage	increased	decreased
Shunt-Voltage	decreased	decreased
Series-Current	increased	increased
Shunt-Current	decreased	increased

8.4.3 Many teachers do not appreciate that digital equipment can be misused or applied. A recent reference (E.T.I. 1984, 47), included a warning that unless a meter shows true R.M.S. eg. Thurlby, (also BEWA Model 3610 etc), it finds either average or peak values and divides by a fixed factor. The meter may be no good unless the waveform is sinusoidal and as many practicals and projects involve square waves, this point should be made clear to students by means of a suitable experiment. Significantly the same reference mentioned circuit overloading by both oscilloscopes and frequency counters.

8.4.4 The (W.J.E.B. 1985) equipment recommendations for Systems Electronics included five double beam C.R.O.'s for a class of twenty students. However, at the price quoted the C.R.O.'s may not provide the range of 10MHz recommended by (Grace 1981) and consequently a C.R.O. may not be suitable for the range of frequencies encountered in project work.

Although many centres standardise on equipment such as C.R.O.'s it may be preferable to use a variety of models:

i) Students become more flexible in their use of equipment.

ii) C.R.O.'s can be purchased which offer differing facilities eg. TRIO CS1575 has an X axis amplifier, the HAMEG 204 has a component tester etc.

iii) By spreading purchases over a period of years the inevitable problem of replacements may be more easily accomodated.

iv) A mix of 'good' and 'not-so-good' C.R.O.'s will provide the range of facilities required within a total budget.

8.4.5 The problem of frequency range can be encountered on what at first appearances could be given as a simple 'O' level experiment: the ring oscillator, Diagram 8.4.

The measurement of frequency allows the propagation delay to be calculated using the equation.

$$f = \frac{1}{2(\text{No. of gates})\ (\text{propagation delay})}$$

At 'O' level, the use of two I.C.'s would seem a reasonable limit so that seven gates could be used.

If 7400 L series I.C.'s are used a frequency of the order of 2MHz is obtained but if the 7400 LS/S/H series are used then a frequency of the order of 10-15 MHz is obtained, outside of the range being used by many centres. Using such a simple experiment, students can be introduced to the significance of code letters, the limits of equipment, also to the idea of using alternative I.C.'s eg. five gates in a 74 LS04.

An extension of this experiment is to then disconnect the ring oscillator from its power supply when the C.R.O. continues to display a signal of the order of several MHz. An 'O' level student will afterwards be more cautious about the validity of observations, an 'A' level students may be led to realise that in some way the ring oscillator acts as tuning aeriel to the C.R.O.

Diagram 8·4 : Ring Oscillator (8·5·5)

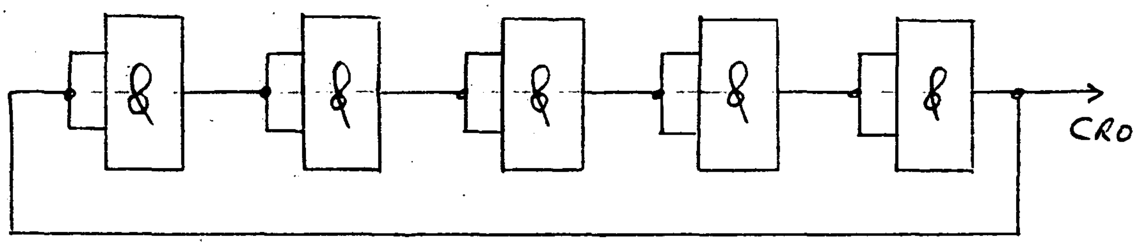
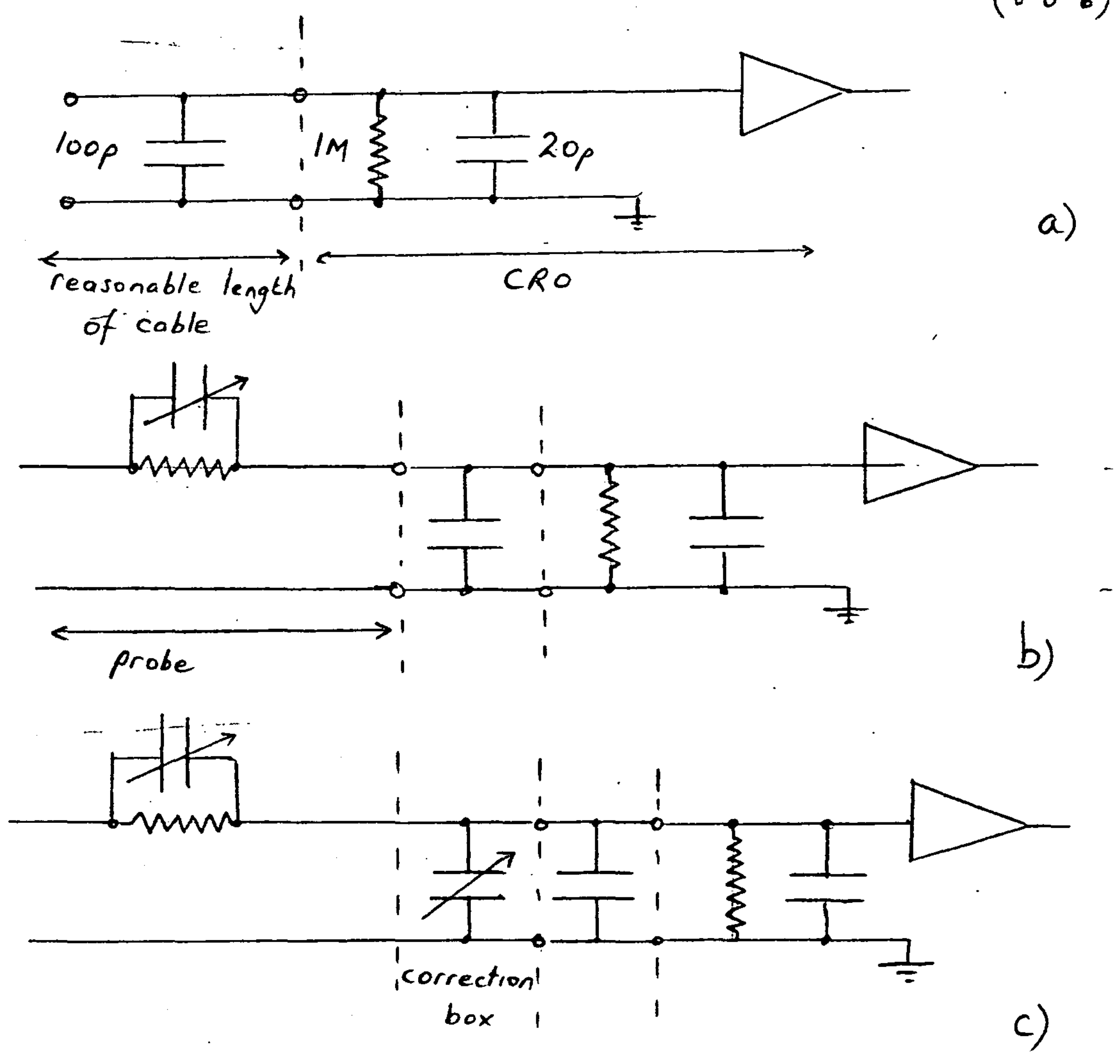


Diagram 8·5 : Representation of C.R.O

a) normally b) with attenuation c) with capacitive loading (8·5·6)



A further extension to the experiment is to observe the display using both the 10x1 and 1x10 ranges if a suitable C.R.O. is available. These will often give differing amplitudes introducing the importance of using manuals to check on calibration and matching.

8.4.6 Further demands on the C.R.O. are probable in the Medical Electronics option of the W.J.E.C. proposals. When testing voltage signals from nerve and muscle cells the measuring instruments needs "to offer an input resistance at least two orders of magnitude greater than the equivalent source resistance and to generate a bias current sufficiently small not be disturb the impaled cell or produce a significant offset potential.": (Purves 1983, 31). The R.C.A. CA3130 offers an input resistance of 1T with a bias current of 5pA at room temperature in contrast the 741 with its 800nA bias is unsuitable.

Thus at 'O' level students will be required to appreciate the use of probes A C.R.O. can be represented as shown in Diagram 8.5a.

At 1MHz this circuit has an A.C. impedance of approximately 1k and the output resistance of the circuit being measured could be up to 100 . However, at 10MHz the output resistance would be limited to 10 . To obtain an improved connection a passive probe may be used eg. 10:1 attention as shown in Diagram 8.5b. and to extend the band-width capacitive or inductive loading of the C.R.O. may be used eg. capacitive as shown in Diagram 8.5c.

The use of such probes requires trade-offs between rise-time and signal loss so that active probes are preferable; these offer low capacitance, high resistance and use a correctly terminated cable.

At 'A' level, this consideration of test equipment leads to the concepts of band-width and rise-time: A.E.B. Electronic Systems Notes for Guidance 3.5, 3.6. A typical input capacitance of a high quality amplifier is 4pF with a source resistance of 50M giving a rise-time of 2.3Rc = 460 s. This is too slow for some neurophysiological applications so the students may be introduced to the concepts of matching, first using the emitter follower to increase the input impedance and then with boostrapping to modify the input impedance to a fraction of a pF which is satisfactory.

8.5 PROGRAMMABLE AND MEMORY DEVICES

One of the aims of the Information Technology Year and the M.E.P. Programme was to involve school children in the use of microcomputers and related electronic devices. An editorial in Wireless World, September 1982 urged the need for teachers to use the computer as an aid.

Other than computer assisted learning and simulation, the computers may be usefully applied as laboratory instruments. Also microprocessors may be used to create new concepts of laboratory instrumentation. Constraints of time and space only allow the instrumentation usage to be considered.

8.5.1 (Clark, Jones and Lambert 1982) described how they were working on "a versatile instrument which can:

a) take the place of a wide variety of laboratory instruments

b) enhance the performance of existing instruments

c) automatically record a sequence of readings for later recall at time intervals which can range from multi-seconds to days

d) be used to teach the elements of digital electronics and control technology."

Clark et al pointed out that modern microcomputers were unlikely to be either available in laboratories or suitable for this task because of their cost: "The instrument we are developing would cost a fraction of that of a typical microcomputer scheme." (Lambert 1983, 38) later indicated that further reasons why the use of a microcomputer was considered unsuitable were the problems of providing suitable interfaces and of writing software.

The programme was supported by M.E.P., J.M.B. and A.S.E. and led to the development of a Versatile Laboratory Aid, the V.E.L.A. which was made available to schools at half price support being given by D.T.I. Undoubtedly the equipment is versatile, further development to include different ROM, and EPROM increased the range of applications even further to include use with a printer, microcomputer etc. (Bodey 1984) described how the equipment could be used in radioactivity experiments as a rate-meter, also (Bodey 1985) its use with a Sonometer. (Panter 1984) described how a V.E.L.A. was used to record energy levels across an interference pattern and play the information back on a C.R.O. to distinguish the contribution made by interference and diffraction.

The various V.E.L.A. manuals available were supported with a quarterly Newsletter from February 1984.

Unfortunately conversations with teachers reveal little evidence of the use of this equipment in school laboratories even when project briefs specify transients; as discount funding do not extend to F.E. that educational sector made little use of the V.E.L.A.

(Sparkes 1985) in a consideration of the V.E.L.A. and other programmes to develop equipment wrote "At the risk of becoming very unpopular I think that all these were in the wrong direction." He quoted the case of home computers being cheaper than V.E.L.A. and he observed how much economic factors had altered.

8.5.2 The M.E.P. Analogue Sensor Manual gave details of analogue interfacing for not only the V.E.L.A. but also general purpose microcomputers such as the Sinclair ZX81 and Spectrum models and the BBC B model. Software was given for the BBC B insofar as it has its own built in ADC as well as other useful features, but no software was given for the Sinclair models as they may use any of several external analogue-to-digital converters. The circuits were described as being made for about £5 and capable of an accuracy within 2% with repeatability roughly ten times greater. (Malcolme-Laws 1984) also provided useful information on the use of microcomputers for data collection.

8.5.3 The literature provides an impressive range of experiments in the subject areas of Biology, Physics and Chemistry.

Several experiments using the BBC B were described:

i) (Brankin et al, 1984): the use of several transducers with the BBC B to obtain "appealing" and "convincing" graphics.

ii) (Watson et al, 1983): measurement of capacitor charge decay; also given by (Miller and Underwood 1984).

iii) (Roberts 1984): as an interval timer for linear air track experiments.

iv) (Warren 1984): colorimetric analysis and curve fitting.

v) Marley 1984): demonstration of autocatalysis.

vi) (Baskett and Matthews 1984): computer controlled precision titrations.

8.5.4 References to the use of the ZX81 and ZX Spectrum were also made:

i) (Penman 1984): ZX Spectrum for the investigation of Newtons law of Cooling, giving details of a thermistor detector and an Op-Amp amplifier; also the ZX81 and a laser to measure distance.

ii) (Rossiter and Humphreys 1983): ZX81 in Chemistry to observe a rate of reaction and in Physics to observe free-fall. A Technomatic interface was reported to give "value for money."

iii) (Taylor 1984): ZX Spectrum with an I-pack interface to plot a cooling curve for wax, capacitor discharge, and to demonstrate simple control. Taylor commented on the cheapness of this equipment.

iv) (Swift 1984): gave an example of the industrial use of the ZX Spectrum despite its reputation for dumping programmes and he wrote "Don't despise the humble home computer."

8.5.5 The use of a cheaper home computer offers several attractive features:

i) its cost is compatible with a conventional science department budget being much less than V.E.L.A., BBC B etc.

ii) its use may more probably build onto the students use of a home computer and allow the students to continue work outside of school: (Smith 1983, 367-368)

iii) if a suitable computer was chosen economically this might under-pin the lower end of the market and reduce foreign penetration.

8.5.6 Mention was made of the problem of writing software: (Lambert 1983) one of the aspects which were being considered when (Harris 1983) writing of the use of the computer in Chemistry stated "Many of us regard computers with trepidation". What many science teachers would prefer is readily available interfaces, probes and software that will convert a microcomputer into a laboratory without a need for a knowledge of electronics or assembly language programming.

They would prefer to be able to select a programme and then to use the equipment as simply as either a conventional meter or a data acquisition unit. The latter can be easily used to observe transients but unfortunately units such as Phillip Harris Memory Unit C49700/1 and Grant Squirrel Meter/Logger are more expensive than the V.E.L.A. etc.

In the U.K. (Sparkes 1984) provided some laboratory programmes for the ZX Spectrum and BBC B, and I.C.I. Ltd provided experimental details using the Rexagon. Also firms such as Griffin and George, Phillip Harris and Harley Systems provide interfaces and software to allow the use of the microcomputer to control laboratory equipment etc. Unfortunately, in many instances complete facilities are only easily available for the BBC B model. Even where a wide range does exist for the home computer eg. G & G ZX, the total cost of the equipment is relatively high in a science department budget and it can be difficult to examine and use the equipment before deciding on a purchase. Some of this difficulty originates in the decision mentioned previously of 'a computer in every school' and local decisions, often taken several years ago, to standardise on the BBC B Model.

If teachers are to have an 'ownership' with the development of ideas they should be allowed greater freedom to experiment and try alternative equipment before deciding on policy. I.N.S.E.T. courses should provide this facility.

In U.S.A. the Cambridge Development Laboratories currently advertise software to convert a microcomputer into a laboratory instrument. Also in U.S.A., Micro-phys offer software which includes a range of laboratory experiments allowing students to follow written instructions making observations as the computer checks the data collected making calculations and providing copy etc.

8.6 USE OF 'SIMPLE' COMPONENTS

(Bilsland 1985, 73) wrote of 'IT Education' that it was broader than 'a computer in every school'. There is a danger that the efficiency and versatility of laboratory equipment can distract from the use that can be made of simple components. In the field of chemistry and biology, one journal alone provided several interesting uses of the Op-Amp:

i) (Stock and Walter 1976) used Op-Amps to construct a differentiator to identify $\Delta^2 E/\Delta V^2$, the second derivative at the equivalence point. This approach contrasts with the use of a computer for titration by (Baskett and Matthews 1984) and the use of the Op-Amp relates to the techniques of speed control in some Electronics syllabuses.

ii) (Durrant and Bloodworth 1976) used Op-Amps in an electrocardiograph amplifier unit for use with C.S.E. 'O' and 'A' level groups. This circuit uses Op-Amps as buffers, amplifiers and filters; the device usefully allows the integration of Biology and Electronics. Also the device introduces 'A' level students to a form of filter not included in their syllabus.

iii) (Jackson and McGregor 1978) described the use of an Op-Amp pre-amplifier with a chart recorder.

iv) (Storie and Wham 1983) described an electron-direction indicator which included L.E.D. and Op-Amps; for Electronics students this provides an illustration of the application of a simple comparator circuit.

Another example of the use of simple components rather than equipment is in the demonstration of L-C-R effects. A sweep generator may be used in this experiment and the envelope on a C.R.O. provides the shape of the L-C-R frequency chracteristic. Using either a sweep generator eg. Thandar TG102 or a V.E.L.A. a ramp voltage is required to obtain the sweep and the laboartory bench is very quickly covered with a range of equipment. An alternative procedure is to use a voltage controlled oscillator I.C. with an integrator; (Sutcliffe 1979) described a circuit which may be adequately extended for this purpose.

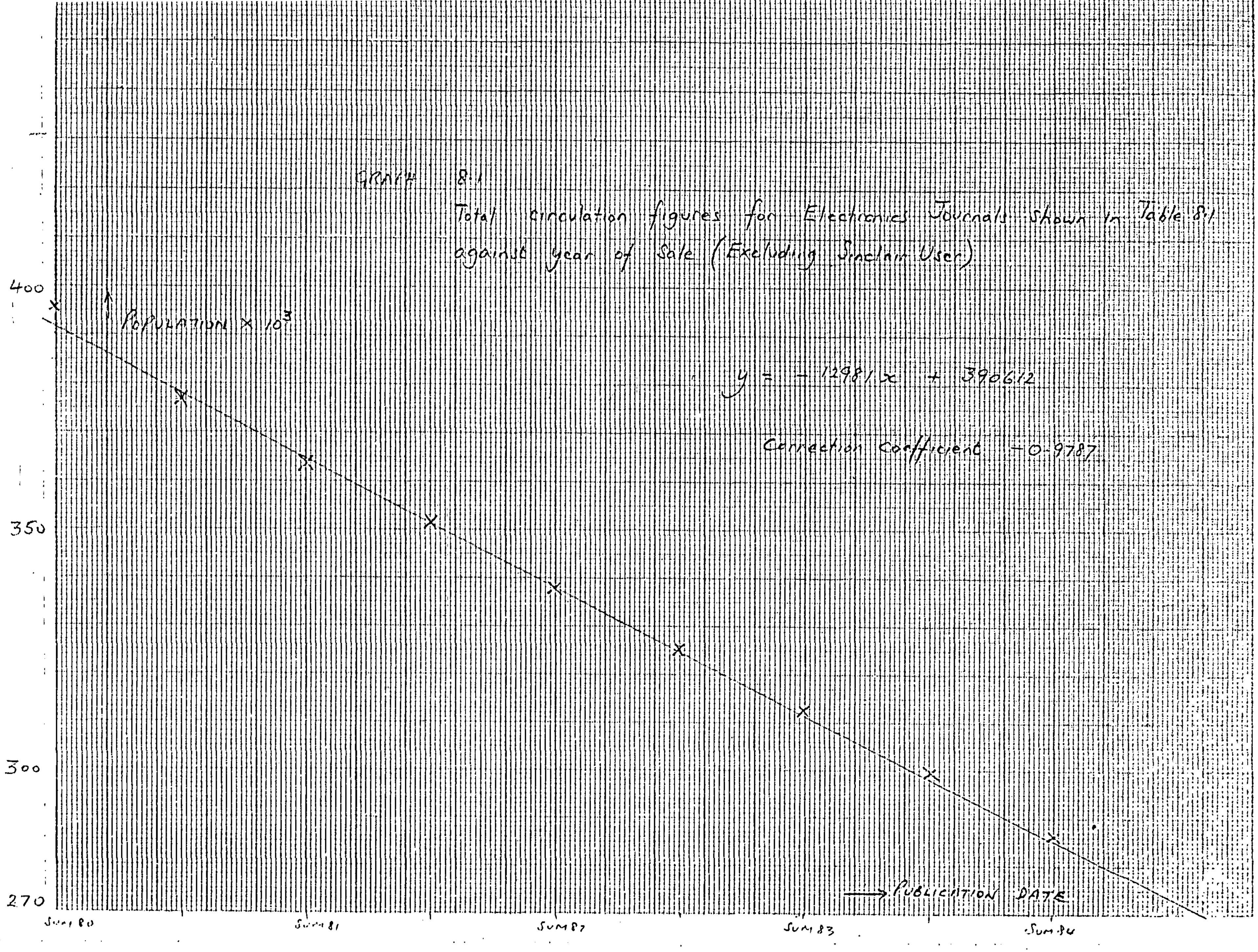
Thus the use of simple components can allow the students to relate applications to topics within a syllabus while at the same time integrating ideas/applications etc., from other subject areas. This activity relates usefully to project work and has the advantage of reduced cost compared with the use of purchased equipment.

8.7 JOURNALS AND TEXT-BOOKS

The 132nd Edition of Berns Press Directory published 1984 U.K. states in its Introduction: "Magazines supporting the microchip revolution dominate the new titles listed in the Periodical Section this year; a wider selection of these titles is published in the U.K. than any other country excepting U.S.A." The Directory included 6,500 titles of which 322 titles were under audio, Visual, Computing and Electronics headings. 63 of the 322 were new since the last edition of the Directory published 1983.

The more popular titles are described in the Appendix; details are given also of other journals which are often available in public libraries etc.

The Adult Bureau of Circulations limited by Guarantee circulation figures for the more popular journals covering the period 1979-84 are given in Table 8.1. These circulation figures show a consistent decline for most journals, a significant exception being Sincalir User, this is shown dramatically in Graph 8.1. Should the decline continue then some titles may cease publication. (Johnstone 1984) made the same point in connection


GRAPH 8.1
Total circulation figures for Electronics Journals shown in Table 8.1
against year of sale (Excluding Sinclair User)
y = - 12981x + 390612
Correction coefficient -0.9787
POPULATION × 10³
400
350
300
270
SUM 80
SUM 81
SUM 82
SUM 83
SUM 84
PUBLICATION DATE

with the microcomputer magazine market.

Just as schools are directed to certain apparatus by Government discounts it would seem sensible to direct schools to certain magazines so that the schools can reliably accumulate a reference facility. Also as losses do occur due to pilfering, accidents, mis-placed student enthusiasm etc., it would seem sensible to direct attention to those journals which are available for reference in the region. A list is given in the Appendix of those titles available in Tyne and Wear. Of the centres listed the Central Libraries at both North Tyneside and Newcastle are suggested as being particularly good in electronics and coin photocopying facilities exist. The Newcastle College of Arts and Technology is not open during the Summer months. Newcastle Polytechnic opens 9.00am - 5.00pm Monday to Friday during the Summer months.

Although there are only a few text-books which broadly cover any of the Electronics courses considered, there is a very wide range of books suitable for use within the courses. Most of the G.C.E. Boards recommend a reading list but generally they omit any reference to text books prepared for T.E.C. courses eg. Pitman publish several useful books on Electronics and on Radio Systems written by Green. Faced with restricted funds available within a department, and widely reported shortages in library funds many teachers comment on the difficulty of making books available for use on a course.

It would be useful if teachers could have the opportunity to compare texts before making a choice and also if special funding could be made available to enable sufficient provision of books to be made when a course commences.

At present the A.E.B. Board use B.S.3939 symbols for Electronics many other Boards and journals use M.S.806Bsymbols. In future a new international standard given in I.E.C. Publication 617:12 Binary Logic Elements will be increasingly used, (Kampel 1985), and teachers should be careful about the choice of text books in the near future.

8.8 CONCLUSION

A considerable amount of information is available to the teacher of Electronics but not all of the information is either readily available or pertinent. Several literature sources are very useful and as I.N.S.E.T. develops it should make an important contribution.

It would seem unreasonable to expect every teacher to meet every problem individually and it may be useful if L.E.A.'s were able to support local teachers groups for those involved in Electronics. The social contact and sharing of problems would assist in solving problems and giving the subject an 'identity'.

The provision of I.N.S.E.T. needs very careful consideration, teachers should not be regarded as 'passive technicians' and time available for I.N.S.E.T. should concentrate on those areas which cause interested teachers the problems.

SECTION 9. CONCLUSION

"Ad Meliora?"

"The 'demise' of U.K. Engineering capacity especially in its international role is attributed by many to the fact that Education never really attempted to assimilate 'Engineering' into the curriculum; Engineering lacked a certain status and 'respectability' compared with Science. It could be an economic disaster for the U.K. if the significant new technologies were now omitted from the curriculum."

The recent Government initiatives appear to be a co-ordinated innovation strategy designed to encourage the development of technology, problem-solving skills etc., within the curriculum. Several of the initiatives will accelerate the already growing interest in Electronics, however the way in which this interest will affect the curriculum is difficult to assess. A key determinant will be the provision of resources made vis initial teacher training, I.N.S.E.T., equipment, laboratories, and staffing. The level of financial commitment may be such that L.E.A.'s may need to encourage specialist provision (Edwards 1983, 15) on the bias of viable centres, L.E.A.'s may have to be more prescriptive, and L.E.A.'s may have to surrender some autonomy if they are to respond quickly (Gwyn 1982, 364). An example of the latter was the 1985 Budget announcement that the Manpower Services Commission was to be invited to administer an support should have a grater flexibility to allow adaption to emerging factors of growing economic stringency in schools, changing availability of equipment etc. A close examination should be made of the I.N.S.E.T. needs of both adminsitration and teachers.

If the administrators wish to develop technolgies within the curriculum, they can not continue to display 'two-images': (MacDonald and Walker 1976) (see 4.3.3.1), one being to ask for development the other being to leave the teachers of the new technology to do the bargaining for resources in competition with traditional subject areas. The administrators concerned should be given the opportunity to recognise the problems of the rate of change, and the material and staff resources required (Gross et al, 1971) (see 4.3.1.2) - if not already given - so they can make a coherent decision on the re-allocation of those resources available. The administrators can encourage a climate in which there is a tolerance and trust of new ideas, (see 4.3.4.6), and which allows development to originate within Sections/Departments (see 4.3.1.4). In making appointments, administrators may recognise that although staff atrophy may not be critical: (MacDonald and Walker 1976) (see 4.3.4.7), nevertheless the work of (House 1974) (see 4.3.4.1) suggested that place bound staff are more likely to support 'difficult to adopt' innovations than career bound staff. The work of (Malone and Crone 1978) (see 4.3.5.9) also suggested that little real help may be given by those who support a project seeking 'escape from boredom'.

Some of the teachers I.N.S.E.T. requirements were given in

Section 8.2, it is not enough to merely demonstrate, display and describe either equipment or topics which teachers themselves are quite capable of grasping. I.N.S.E.T. courses should be concerned with:

i) instilling the concept and relating it to accepted areas: (Rogers and Shoesmith 1971) (see 4.4.2.ii) using a Normative re-education strategy (4.4.9.ii)

ii) strengthening a role identity (Williams 1966) (see 4.2.3); also (Miles 1964) (See 4.4.2.ii), perhaps by setting up a 'working party' (see 6.3.1.3.vi).

iii) dealing with 'problem areas', and individual needs (see 6.3.3.1.3.iv) related to provision and use of resources, project work etc. (Cane 1967) in a summary of I.N.S.E.T. provision indicated the importance of 'new' and 'developing' ideas.

In view of the rate of change, the cost and novelty of equipment, I.C.'s etc., teachers should not be expected to make decisions only on the basis of information in catalogues. Staff whether in schools or F.E. should be given the opportunity of ready access to those resources which are available to determine the suitability of ideas, equipment etc., in terms of the needs of themselves and their school before decisions are made. If the subject is to develop with the co-operation of staff, the use of 'de-skilling' packages does not seem a reasonable approach as staff will then accept the materials and not the concept bceoming merely technicians: (Nicholls 1983) (see 4.3.5.5, 4.3.5.8). Also the present system of presenting local budget estimates, ordering, and virement may be seen as an outmoded accountancy procedure which does not allow sufficent flexibility in a situation where sooner or later equipment necessary for a course will break.

The growth to date in Electronics reflects the commitment of teaching staff; the impact of current Government initiatives and the provision of suitable assistance to those staff who will become involved in future may be expected to contribute to further growth and new problems. What is required is an imaginative view of how Electronics can contribute to the curriculum in future and a flexible policy which will quickly accommodate future problems and change.

APPENDIX

C.P.V.E.

Category 2 - Technical Services

Cluster - Information Technology

and Microelectronics Systems

CATEGORY: TECHNICAL SERVICES

CLUSTER : INFORMATION TECHNOLOGY AND MICROELECTRONICS SYSTEMS

EXPLORATORY MODULE : THEORY AND PRACTISE

PRE-REQUISITES

Has undertaken introductory studies in the general categories of "Technical Services" or "Business and Administrative Services" or "Production" or "Distribution".

RATIONALE AND PURPOSE

An introduction to Technology and Microelectronics systems enabling:

1. Role exploration within Information Technology and Micro-electronics.
2. Development of core skills.
3. Acquisition of entry level skills into employment.
4. Acquisition of transfer skills.

These purposes must be taken together with those for the project module for Information Technology, and Microelectronics systems, since the overall purposes of exploration are realised by the two modules together.

LEARNING OUTCOMES AND REQUIRED EXPERIENCES

In real or simulated situations (including projects) the students will:

1. Have recorded experiences and learning in one or more selected activities in a range of contexts of the cluster.
2. Demonstrate progressive achievements in appropriate core skills.
3. Record development of his/her individual interests and skills in selected components of the cluster.
4. Know and state the uses of information technology and micro-electronics systems in each of the four contexts.
5. Explain the significance of information technology and developments in microelectronics to the economy and the community.
6. Appreciate the general features of Information Technology and Microelectronics systems and how they are applied in individual commercial and domestic situations.
7. Understand how a system is designed and implemented.
8. Understand how information is processed, stored, retrieved and communicated.
9. Appreciate the need for security of information and copyright.
10. Study and record the organisational structure of a local information technology department/agency or microelectronics company.
11. Review the range and scope of occupational roles in local information technology and microelectronics agencies.

12. Know the employment and career prospects within the cluster and assess his/her personal prospects.
13. Know and appreciate the expectations of employers in relation to entry level workers in these fields.
14. Demonstrate the ability to re-deploy the skills learnt to new situations in this or a related cluster.
15. Be able to idenitfy suitable modules for further exploration or preparation studies.

<u>SCOPE</u>

The relevant cluster plan defines the cope of this module. The outcomes above will be fulfilled through a study of:

1. Information Technology and Microelectronics in business, industry and the home.
2. The effects of information technology and microelectronics on the economy and on individuals.
3. Systems as Input, Process, Output : feedback.
4. Input devices, eg. Keyboard, optical reader, transducers.
5. Process devices, eg. analogue controllers, logic gates, microprocessors, C.P.U.
6. Output devices, eg. printers, V.D.U. controllers.
7. Storage devices, eg. tape, disc: information transfer systems: telephony, eg. Prestel; telegraphy, eg. Telex, teletext; Radio, eg. satelite.
8. Nature of signals : analogue, digital, modems.
9. Software : applications packages, commercial and user

produced, eg. stock control, database, wordprocessing.

10. Simple programming : algorithm, testing, coding, data preparation, debugging, documentation.
11. Laws and regulations governing health and safety, welfare and security.

PROGRESSION POSSIBILITIES

1. Preparatory modules in Information Technology and Micro-electronics systems.
2. Direct entry into specialist courses at craft and technician level according to attainment.
3. Direct employment in industry.
4. Preparation for adult life.

RELATIONSHIP TO PROGRAMME AS A WHOLE

1. This module must be pursued concurrently with the project module.
2. Opportunities exist within this module for the development of core processes, particularly those relating to personal and career development as part of role exploration. Active learning strategies as suggested in the module descriptor will permit development of many other common core skills.
3. Will normally precede or run concurrently with preparatory modules in the same cluster.
4. May accompany exploratory learning in another cluster.

The additional information below is for guidance of centres on the interpretation and implementation of the module.

EXAMPLES OF ROLES FOR EXPLORATION

See cluster plan.

SUGGESTED TEACHING AND LEARNING APPROACHES

This module complements the asociated project module but provides wider ranging experiences for exploratory purposes. The student should be encouraged and guided to adopt active rather than passive learning methods with the aim of generating autonomy and a pro-active approach to learning. Active learning which may be particularly appropriate to this module include:

1. Visit to school/college computer rooms and elctronics workshops and discussion with personnel.
2. Visits to industrial and commercial installations followed by reporting back to group.
3. Structured assignments relating to microprocessors and micro-computers.
4. Study and interpretation of instruction manuals for equipment.
5. Work experience/short attachments in the locaility.
6. Investigation roles in the locality.
7. Case Studies.
8. Visiting speakers from business and industry.
9. Films and videos on large scale installations.

10. Consumer surveys on the use made of microcomputers in business.
11. Practical work in electronics.
12. Practical work with microcomputers.
13. Work sampling to investigate roles in an industrial and commercial environment.
14. Simple project to collect and analyse and display data.

NOTES

1. Active learning methods should be supported by opportunities for reflection and discussion of, experience to bring about understanding of principles, concepts and generalisations.
2. The project module will provide concurrent opportunities to apply and extend in some depth the knowledge/skills generated in this module.
3. Students should have the opportunity to explore roles within a wide variety of contexts.

CATEGORY : TECHNICAL SERVICES

CLUSTER : INFORMATION TECHNOLGY AND MICROELECTRONICS SYSTEMS

EXPLORATORY MODULE : PROJECT

PRE-REQUISITES

Related introductory experience, personal and vocational counselling.

RATIONALE AND PURPOSES

Project modules are designed to ensure achievements centred on locally developed projects. Their primary purposes are to:

1. carry the learning and application of appropriate core objectives.
2. enable role exploration through direct structured experiences.
3. ensure the development and application of generalisable vocational skills.
4. develop autonomy and the acceptance of reponsibility.
5. develop employment entry skills.
6. give a basis for progression within and out of the course.

LEARNING OUTCOMES

The student will:

1. take responsibility for his/her own contribution.
2. take responsibility for a group outcome.
3. handle information.

4. present an informed judgement.

5. respond to changing needs and circumstances.

6. select between alternatives.

7. proceed in a systematic manner.

8. manage and deploy time and other resources.

9. monitor and sustain an activity/process/environment.

10. complete a course of action/meet agreed targets.

SCOPE AND REQUIRED EXPERIENCES

1. The module should encompass all key elements of project-based learning:

   selecting a topic/problem/product

   research/feasibility study

   problem solving/decision making

   planning

   production/activity/implementation

   review and evaluation

   recording/reporting/presentation

2. The module will lend itself to the development of competences within all core areas particularly those relating to problem solving, practical skills, social skills and creative development.

RELATION TO PROGRAMME AS A WHOLE

The Project module should be pursued concurrently with relevant Theory and Practice module.

POSSIBLE CONTENT AND APPROACHES

1. The complementary nature of the Theory and Practice, and the Project modules needs to be made clear. The Theory and practice module provides experience across the range of the activities in the cluster. It will generate knowledge of practice across the wider field. The Project module allows a study in depth of selected aspects of the cluster. Although some of the same explanatory and core aims will be addressed by both modules, more emphasis will be given to the process objectives of the core in the Project module.

2. The project(s) should be substantial to give scope for the learning outcomes to be achieved. Projects may be of several types, such as, product based, service based, or investigatory. Whatever their type, the projects should acquire status, significance and commitment by adopting approaches such as student negotiation and choice, the fulfilment of actual demand/need and full opportunities for feedback. The following examples of projects might be appropriate:

   (a) Prepare an illustrated report on the history and development of information technology.

   (b) Prepare a report on the flow of information in a school/college and design a new system based on available technology.

   (c) Design and install a secuirty system including a variety of detection and alarm devices.

APPENDIX

Ordinary National Certificate in Sciences - Northern Counties Technical Examination Council

Session 1965 - 66

Basic Physics 01 Section 3 Aspects of Atomic Physics

b. Release of electrons by heat, light, particle bombardment and the action of electric fields. Deflection of an electron beam in electric and magnetic fields, dtermination of e/m, the electron volt. Introduction to thermionic and semi-conductor devices (cathode ray tubes, static characteristics of fiode and triode, junction rectifier).

Elective Physics 02 Section 1 Elements of Electronics.

1 ELEMENTS OF ELECTRONICS

Revision of properties of the electron and qualittative account of the simple Bohr model of the atom.

Account of the constructional features of a thermionic valve rectifier, together with diode characteristics. Range of application of this type of rectifier with brief account of gas-filled devices. Elementary account of semi-conduction. For of construction and characteristics of p-n junction. Comparison of semi-conductor and thermionic rectifier in terms of uses and characteristics.

Rectification of an alternating supply. Approximate estimation of ripple output and elementary account of filters.

Explanation of the action of a triode. Valve parameters, their definitions and their determination from static characteristics and dynamic methods.

Introduction to transistor as a circuit element. Comparison with triode amplifier. Emphasis on circuit element values.

Simple R-C coupled amplifier, both valve and transistor, with emphasis on the range of values of circuit elements for normal audio applications, together with a sound physical explanation of the function of each.

The C.R.T. treated as an extension of the triode. Basic constructional features and uses of electrostatic and electromagnetic deflection types of tube. Uses of the C.R.O. as a display and measuring instrument.

The simple gas discharge tube time base.

NB: Where possible the qualitative treatments should be supplemented with the appropriate calculations, provided that practical or physical points are illustrated and that the mathematics is within the compass of the students.

(FOOTNOTE - For the significance of the asterisk see General Note for Guidance No.2 on Chemistry and Physics Syllabuses.)

2. SOUND REPRODUCTION AND RECORDING

Acoustic resonance in a pipe. Simple account of room acoustics, standing waves, and reverberation time and the factors which affect it. Constructional features of the moving coil loud-speaker. Account of the basic physical features of disc, tape, and film recording techniques, their advantages and limitations.

The essentials of the pressure and the pressure gradient microphone, together with an outline account of the basic features of practical and audio amplifier design.

3. ILLUMINATION

Definitions of source strength and intensity of illumination. Lambert's cosine law. Comparative account in outline of types of light source, range of application, styrength and spectral distribution. Photelectric cells, review of types of and ranges of application.

4. RADIOACTIVITY

Revision of nature and properties of the principal radiations. Law of simple radioactive decay, half life. Outline account of the principle of operation of the geiger counter. Applications illustrating fully the range of application of radio-isotopes. Elements of radio-logical protection.

5. APPLIED HEAT

Qualitative review of the methods of measuring temperature, with particular reference to those which have an electrical output, leading to a brief account of temperature recording and control. Principles of refrigerating machines.

6. HIGH VACUUM

Descriptive account of the principles of operation of the rotary and the diffusion pumps. Brief outline of the physical principles which may be employed to measure "low pressures", with particular reference to the McLeod and Pirani gauges. Mention of application of vacuum, technique to electron tube manufacture and vacuum deposition.

7. PRINCIPLES OF INSTRUMENT DESIGN

Basic principles of kinematic design as applied to instruments employing rectilinear or rotational movements. Uses of leaf springs to eliminate backlash and friction. Uses of strip hinges and twisted strip magnifiers. Spring energy stores and constant torque systems. Reilient mountings.

NB: - This subject should be developed so that the student can appreciate the basic points of good instrument design. It should also give the opportunity for reasonable constructional sketches of simple instrument movements.

By 1975

BASIC PHYSICS (01)

1. ELECTRON PHYSICS

Simple atomic structure, model; ionisation; spectrum; conductors and insulators. Conduction of electricity in gases, liquids and solids; charges and currents.

Descriptive treatment of semi-conductors, transistors, photo-conductive cells.
(9 hours)

2 MAGNETISM AND ELECTRICITY

Quantitative treatment of the magnetic field due to a current in a conductor and the forces due to interaction; permeability of free space, relative permeabilities. Examples with reference to simple motors, moving coil meters.

Linear and non-linear characteristics; conductivity. Potentiometer cicruits (simple version, together with outline of industrial types).
(17 hours)

BASIC PHYSICS (02)

1. ELECTRON PHYSICS

Forces on charges in magnetic and electric fields with reference to e/m measurements, cathode ray tube.

Description of thermionic, photo-electric, secondary and field emission of electrons with reference to practical devices, including valves, vacuum and gas-filled, photo-multipliers and X-ray tubes.
(14 hours)

ELECTIVE PHYSICS (02)

1. ELECTRICITY AND MAGNETISM

Conduction in Solids.
Energy levels in solids; differences between conductors, semi-conductors and insulators; concept of the "hole" current flow; Hall effect; impurity semi-conductors, p-type and n-type, conductivity; effect of heat and light.

Ferromagnetism
Characteristics of ferromagnetic materials; susceptibility, permeability; the hysteresis loop and its signifance; domains; soft and hard magnetic materials, ferrites. The transformer.

Varying Electric Currents
Growth and decay of current in inductive circuits; charge and discharge of a capcitor; time constant; oscillatory discharge.

Phasor approach to alternating current circuits, r.m.s. and peak values (for sinusoidal waveforms); R, L and C separately, in series, in parallel; phase difference, reactance, impedance, power factor, resonance, Q.
(40 hours)

2. ELECTRONICS

Transistor and valve considered as an a.c. generator, equivalent circuit of amplifier, input and output impedances, relative phase of input and output, principles os positive and negative feedback, including transistor and valve oscillators.

P-n junction and Zener diodes. Junction and field effect transistors. Thermionic diode, temperature and space charge limitations, cathode materials. Brief discussion of vacuum and gas-filled triodes, multi-electrode valves. Cathode ray tube construction, including description of electric and mnagnetic focusing and deflection in oscilloscope and television types; tube control and simple time base circuits in oscilloscopes. Applications of semi-conductor and thermionic devices to include smoothed and stabilised power supplies, simple amplifiers, oscillators and switches.
(40 hours)

APPENDIX

<u>Technician Education Council</u>

<u>Modified Standard Unit</u>

1 UNIT TITLE Electronics

2 UNIT LEVEL II

3 UNIT VALUE One Design Length 60 Hours

4 PROGRAMMES

The guidelines produced by Programme Committees indicate the standard units that they see for possible incorporation in their programmes or as supplementary to their programmes.

5 PRE-REQUISITE UNITS

TEC U75/004 Physical Science I or equivalent

6 CREDITS FOR UNITS

7 AIMS OF THE UNIT

To introduce students to the electronics principles used in light-current electrical engineering with particular relevance to communications and industrial electronics.

8 SPECIAL NOTES

The recommended selection for programmes in electronics and communications engineering, from the pre-requisite unit Physical Science I (U75/004) is given in the Guidelines to those Programmes.

9 ASSESSMENT ANALYSIS

The following gives the unit breakdown, by topic and types of learning, as a key to the production by a college of its assessment specification for this unit.

Unit/Subject topic area(s)	Topic Area(s) as % of assessment	% of total assessment				
			Intellectual Skills			
		Motor skills	Information	Comprehension	Application	Invention
A	41	10	11	14	6	
B	7	1	2	3	1	
C	12		3	6	3	
D	20	5	5	5	5	
E	20		13	7		
F						
G						
H						
I						
Percentage of assessment for entire unit. →		16	34	35	15	

10 UNIT CONTENT

The unit topic areas and the general and specific objectives are set out below, the unit topic areas are being prefixed by a capital letter, the general objectives by a non-decimal number, the specific objectives by a decimal number; THE GENERAL OBJECTIVES GIVE THE TEACHING GOALS AND THE SPECIFIC OBJECTIVES THE MEANS BY WHICH THE STUDENT DEMONSTRATES HIS ATTAINMENT OF THEM. Teaching staff should design the learning process to meet the general objectives. The objectives are not intended to be in a particular teaching sequence and do not specifiy teaching method, but, for example, practical work could be the most appropriate teaching method for the achievement of the objectives.

ALL THE OBJECTIVES SHOULD BE UNDERSTOOD TO BE PREFIXED BY THE WORDS: THE EXPECTED LEARNING OUTCOMES IS THAT THE STUDENT:

A ELEMENTARY THEORY OF SEMI-CONDUCTORS

1 Understands the simple concept of semi-conductors

1.1 Defines the properties of a semi-conductor in relation to conductors and insulators.

1.2 States the two common types of semi-conductor material as silicon and germanium.

1.3 Explains simply the structure of 'p' type and 'n' type semi-conductors.

1.4 Explains electrical conduction as movement of electrons in 'n' type semi-conductor material and 'apparent' movement of holes in 'p' type semi-conductor material.

1.5 States how a change in temperature affects the intrinsic conduction in a semi-conductor.

1.6 Derives the equation for the Hall voltage effect $\left(V_H = \frac{BI}{Net}\right)$

1.7 Uses equation in 1.6 to characterise carriers.

2 Knows behaviour of a p-n junction with forward or reverse bias.

2.1 Draws a p-n junction connected in the reverse bias mode, indicating current flow in the diode and the external circuit.

2.2 Draws a p-n junction connected in the forward bias mode, indicating current flow in the diode and external circuit.

2.3 Measures the current flow through a p-n junction connected in the foward bias mode.

2.4 Compares the junction potentials of germanium and silicon diodes when connected in the forward bias mode.

2.5 Sketches the static characteristic for a diode.

2.6 Compares typical static characteristics for germanium and silicon diodes to illustrate difference in forward voltage drop and reverse current.

2.7 Explains the importance of considering peak inverse voltage of the diode.

2.8 Demonstrates the breakdown effect.

3 Knows simple applications of semi-conductor diodes.

3.1 States simple applications of the available range of:

(a) Power diodes

(b) Zener diodes

(c) Signal diodes

3.2 Sketches waveforms of applied a.c. voltage and load current for diode circuits which provide half-wave and full-wave rectification into a resistive load.

3.3 Observes and measures the effects of connecting a smoothing capacitor across the load resistor in half and full-wave rectifier circuits upon the diode current waveform, the load current waveform, the load p.d. waveform and the inverse voltage applied to the diode.

3.4 Sketches a circuit diagram for a stabilised voltage source including a Zener diode and a series resistor.

3.5 Calculates the values of series resistor R in a simple Zener stabilising circuit for the conditions of:

(a) varying supply voltage, fixed load

(b) fixed supply voltage, varying load

4 Knows the arrangement of transistor electrodes.

4.1 Sketches the arrangement of a bipolar transistor produced from a sandwich of semiconductor materials.

4.2 Identifies the electrodes of the bipolar transistor as emitter, collector and base.

5 Knows the modes of connection of a transistor.

5.1 Sketches the circuit diagrams for the common base,

common emitter and common collector modes o
connection.

5.2 Compares the relative values of input and outpu resistances for the three modes of connection.

5.3 Defines the short-circuit current gains of a transisto connected in the common base (α) and the common emitte (β) modes.

5.4 States the relationship between α and β .

6 Knows the static behaviour of a transistor.

6.1 Sketches a common-base mode test circuit diagram fo dtermining the static characteristics.

6.2 Describes the method of obtaining the common-base mod static characteristics.

6.3 Discusses given typical families of curves of Ic/Vc (output characteristics):

Ic/Ie (transfer characteristics)

Veb/Ie (input characteristics)

6.4 Sketches a common emitter mode test circuit diagram fo determining the static characteristics.

6.5 Measures the common emitter static characteristics.

6.6 Plots and describes typical families of:

Ic/Vce (output characteristics)

Ic/Ib (transfer characteristics)

Vbe/Ib (input characteristics

6.7 Determines the values of α and β from giv characteristics.

6.8 Determines the value of input resistance from given input characteristics.

6.9 Determines the value of output resistance from given output characteristics.

B CATHODE RAY TUBE

7 Knows the principles of operation of a cathode ray tube.

7.1 Labels a diagram of a C.R.T.

7.2 Explains the functions of the following:

(a) electron gun

(b) focus control

(c) intensity control

(d) blanking pulses

7.3 States that deflection can be produced by electric and/or magnetic fields.

7.4 Demonstrates the use of timebases and of vertical and horizontal deflection controls.

C SMALL SIGNAL AMPLIFIERS

8 Knows the circuit and operation of a small signal common emitter amplifier.

8.1 Draws the circuit diagram of a single stage amplifier having a load resistor R .

8.2 Shows that the supply voltage $V_{cc} = I_c R_L + V_{ce}$.

8.3 Explains that bias is required to give a selected quiescent operating point on the output characteristic.

8.4 Sketches the circuit diagram and explains the action of a simple bias arrangement consisting of a resistor connected between V_{cc} and base.

8.5 Explains the effect of a small sinuisoidal current input on the quiescent condition.

8.6 States that voltage phase inversion occurs between input and output signals.

9 Constructs and uses a d.c. load line on transistor characteristics.

9.1 Constructs the load line on a given set of output characteristics of a common emitter amplifier for a stated value of load resistance.

9.2 Estimates the r.m.s. voltage output from the load line for given quiescent conditions and given input signal.

9.3 Determines the voltage gain Av from the static characteristics assuming a given input resistance.

9.4 Determines the current gain A_i from the static characteristics.

9.5 Calculates the power gain Ap in dB.

9.6 Describes thermal runaway of a transistor.

9.7 States the reasons for use of heat sinks.

10 Understands automatic biasing of small signal amplifiers.

10.1 Explains with the aid of sketches, simple methods of biasing a transistor amplifier stage.

D AMPLIFIERS

11 Understands Basic Amplifier operation and properties.

11.1 Defines input impedance.

11.2 Defines voltage gain.

11.3 Defines output impedance.

11.4 Measures 11.1 to 11.3 for a given amplifier.

11.5 States condition for maximum power output.

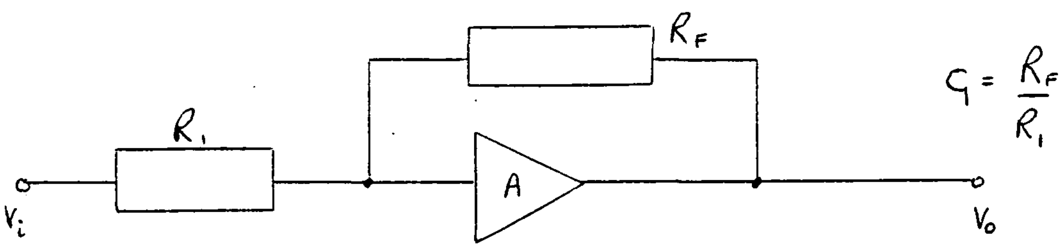
11.6 Explains the advantages of amplifiers with high input impedances.

11.7 States that an ideal operational amplifier has large gain and high input impedance.

11.8 Describes positive feedback.

11.9 Describes negative feedback.

11.10 Explains operation of the circuit shown.

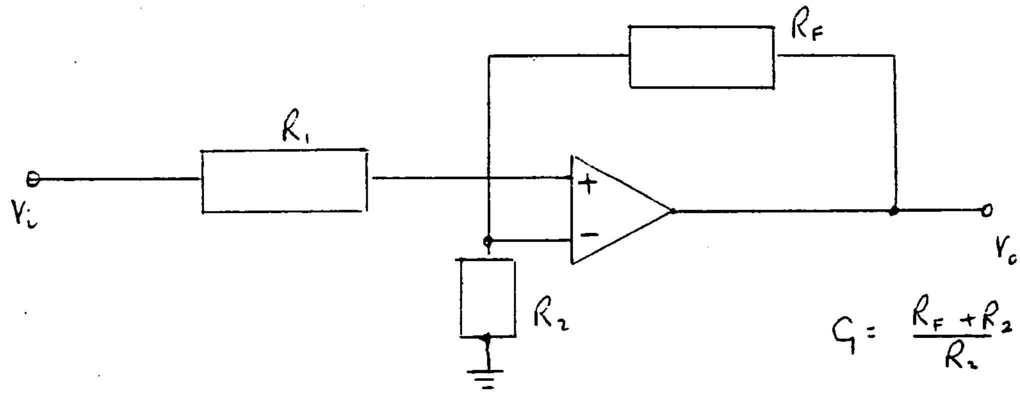


11.11 States gain for circuit shown in 11.10.

11.12 Builds the circuit in 11.10 using an integrated circuit operational amplifier (eg. 741) measures the gain.

11.13 Determines by experiment the variation of gain with frequency of the amplifier in 11.10 and states its bandwidth.

11.14 Explains how an operational amplifier can be connected to given an output in phase to input.



11.15 Uses manufacturer (or suppliers) literature to select componenets of appropriate values to construct a non-inverting amplifier of specified gain using an operational amplifier.

11.16 Constructs an amplifier as specified in 11.15 and measures its gain.

11.17 States the meaning of drift.

11.18 Explains how a differential amplifier can overcome the problem of drift in DC amplification.

E WAVEFORM GENERATORS

12 Knows typical oscillator waveforms.

12.1 Sketches ouptut waveforms of oscillators in common use:

sinusoidal, rectangular, saw tooth.

12.2 States the common uses of the waveforms set out in 12.1

13 Knows the principles of simple sinuisoidal oscillators.

13.1 States that a sinewave oscillator is an amplifier with positive feedback sufficient to maintain its own output.

13.2 States that a sinewave oscillator requires both a frequenecy-determining circuit and a method of self-stabilisation.

13.3 States that the approximate frequency of oscillation of most LC sinewave oscillators is $f_o = \frac{1}{2\pi\sqrt{LC}}$

13.4 Sketches the circuit diagram of a tuned-collector oscillator and an Op-Amp oscillator.

13.5 Describes methods of applying bias in a tuned-circuit transistor oscillator.

F <u>LOGIC ELEMENTS AND CIRCUITS</u>

14 Knows that information can be communicated by two-state signals.

14.1 Gives simple examples of two-state devices.

14.2 Gives simple examples of information being communicated by two-state devices.

15 Understands the function of, 'AND', 'OR' and 'NOT' gates.

15.1 States the logical function of the 'AND' gate.

15.2 Constructs a truth table for a 3 input 'AND' gate.

15.3 States the Boolean symbol for 'AND'.

15.4 Draws the B.S. circuit symbol for an 'AND' gate.

15.5 Recognises superseded B.S. circuit symbols for an 'AND' gate.

15.6 States the logical function of the 'OR' gate.

15.7 Constructs a truth table for a 3 input 'OR' gate.

15.8 States the Boolean symbol for 'OR'.

15.9 Draws the B.S. circuit symbol for an 'OR' gate.

15.10 Recognises superseded B.S. circuit symbols for an 'OR' gate.

15.11 States the logical function of the 'NOT' gate.

15.12 Constructs a truth table for a 'NOT' gate.

15.13 States the Boolean symbol for 'NOT'.

15.14 Draws the B.S. circuit symbol for a 'NOT' gate.

15.15 Recognises superseded B.S. circuit symbols for a 'NOT' gate.

16 Understands the action of simple electronic gates.

16.1 Explains the action of a 3 input diode 'AND' gate.

16.2 Explains the action of a 3 input diode 'OR' gate.

16.3 Explains the action of a transistor when used as a switch.

16.4 Explains the action of a transistor 'NOT' gate.

APPENDIX

Technician Education Council

Standard Unit

1 UNIT TITLE Electronics

2 UNIT LEVEL III

3 UNIT VALUE One Design Length: 60 Hours

4 PROGRAMMES

The guidelines produced by Programme Committees indicate the standard units that they see for possible incorporation in their programmes or as supplementary to their programmes.

5 PRE-REQUISITES UNITS:

TEC U76/010 Electronics II

6 CREDITS FOR UNITS

7 AIMS OF THE UNIT

To develop electronics principles needed as a foundation for a range of specialisms in electronics and communications engineering at Certificate level.

8 SPECIAL NOTES

9 ASSESSMENT ANALYSIS

The following give the unit of breakdown, by topic and types of learning as a key to the production by a college of its assessment specification for this unit.

Unit/Subject topic area(s)	Topic Area(s) as % of assessment	% of total assessment				
		Motor skills	Intellectual Skills			
			Information	Comprehension	Application	Invention
A	12		6	4	2	
B	46	20	20	3	3	
C						
D	20		14	3	3	
E						
F	22		10	12		
G						
H						
I						
Percentage of assessment for entire unit →		20	50	22	8	

C UNIT CONTENT

The unit topic areas and the general and specific objectives are given out below, the unit topic areas being prefixed by a capital letter, the general objectives by a non-decimal number, the specific objectives by a decimal number. THE GENERAL OBJECTIVES GIVE THE TEACHING GOALS AND THE SPECIFIC OBJECTIVES THE MEANS BY WHICH THE STUDENT DEMONSTRATES HIS ATTAINMENT OF THEM. Teaching staff should design the learning process to meet the general objectives. The objectives are not intended to in a particular teaching sequence and do not specify teaching method, but, for example, practical work could be the most appropriate teaching method for the achievement of the objectives.

ALL THE OBJECTIVES SHOULD BE UNDERSTOOD TO BE PREFIXED BY THE WORDS: THE EXPECTED LEARNING OUTCOME IS THAT THE STUDENT:-

A FIELD EFFECT TRANSISTORS

1 Describes the action of a field effect transistor (FET)

1.1 Compares the properties of a FET with valves and bi-polar transistors.

1.2 Describes the basic construction of FETs (junction gate and insulated gate).

1.3 Explains the differences between completion and enhancement modes.

1.4 States the precautions used when using FETs.

1.5 Determines the output and transfer characteristics from given data.

2 Describes the circuit applications of FETs.

2.1 Calculates the stage gain of a FET common source amplifier stage using a resistive load.

2.2 Describes the effect on frequency response of adding an inductive load to the circuit of 2.1.

2.3 Describes the performance of a common source amplifier with:

(a) an inductive load

(b) a tuned circuit load

2.4 States the use and advantages of the FET as a switch.

B <u>AMPLIFIERS</u>

3 Understands the performance of voltage amplifiers.

3.1 States the biasing conditions for Class A, B & C operation in the common emitter mode and the common source mode.

3.2 Lists the main applications of each type of amplifier in 3.1.

3.3 Predicts the performance of a two stage class A common emitter and common source amplifier.

3.4 Describes the following types of interstage coupling:

(a) resistance-capacitance

(b) direct

(c) transformer

3.5 Lists applications of the coupling methods stated in 3.4.

3.6 Measure the frequency response of the circuit in 3.3.

3.7 Measures signal amplitude limits for operation of the amplifier in 3.3.

3.8 Measures the effect on the stage gain and bandwidth of disconnecting the emitter source bypass capacitor.

3.9 Measures the input and output impedance of the two stage amplifier in 3.3.

3.10 States the functions of individual components present in an r-f amplifier.

3.11 Explains the selectivity of a tuned amplifier.

3.12 States the applications of buffer amplifiers.

3.13 States that for maximum efficiency impedance-matching must be used in amplifier systems.

4 Describes the action of a large signal amplifiers.

4.1 Identifies from given circuit diagrams, the following a-f large signal amplifiers:

i) single ended

ii) push-pull

iii) complementary

4.2 Lists the functions of individual components in the large signal amplifier circuits mentioned in 4.1.

4.3 Observes the frequency response, power gain and distortion of an impedance matched a-f large signal amplifier.

4.4 States the reasons for and effects of parasitic oscillations in large signal smplifiers.

4.5 States methods of suppressing parasitic oscillation.

C NOTES

5 Knows basic concepts of electrical noise and its relation to signal strength.

5.1 Defines noise as any unwanted signal.

5.2 List sources of external noise.

5.3 States precautions taken to minimise the effects of external noise.

5.4 Lists the sources of internal noise.

5.5 Defines singal-to-noise ratio in an amplifier or receiver.

5.6 Calculates signal-to-noise ratio in db , given signal and noise power.

D FEEDBACK

6 Understands the general principles of feedback.

6.1 Draws a block diagram of a basic feedback amplifier.

6.2 Defines positive and negative feedback in amplifiers.

6.3 Derives the general expression for stage gain of a basic feedback amplifier.

6.4 States the effect of applying negatives feedback to an amplifier in relation to:

(a) gain

(b) gain stability

(c) bandwidth

(d) distortion

(e) noise

(f) input and output resistances

6.5 Applies feedback principles to practical circuits.

E SIMPLE RESISTIVE - CAPACITIVE NETWORKS

7 Understands the operation of pulse-shaping circuits.

7.1 Sketches and labels a rectangular pulse-wave form showing pulse width, pulse amplitude, rise-time and decay-time.

7.2 Sketches the diagram of an inetgrating circuit.

7.3 Sketches the ouput waveform of an inetgrating circuit when a rectangular pulse is applied to the input when:

(a) the pulse width is much greater than the CR time

(b) the pulse width is much smaller than the CR time

7.4 Sketches the diagram of a differentiating circuit.

7.5 Sketches the output waveform of a differentiating circuit for a rectangular input pulse:

(a) much loner than the CR time

(b) much shorter than the CR time

F OSCILLATORS

8 Describes the characteristics of basic sinusoidal oscillator circuits.

8.1 States that oscillations can be produced by an amplifier with positive feedback.

8.2 Explains the operations of:

(a) L-C tuned oscillator

(b) an R-C oscillator

8.3 Describes class A and class C biasing methods.

8.4 States the factors that affect both the short term and long term frequency stability of oscillators.

8.5 Describes methods of improving the frequency stability of oscillators eg. piezo-electric crustal control.

9 Describes the action of transistor multivibrators.

9.1 States the requirements of a transistor multivibrator.

9.2 Describes three different types of multivibrator:

(a) astable

(b) monostable

(c) bistable

9.3 Describes the action of three different types of multivibrator, by deriving waveforms present around the circuits.

9.4 Explains the need for synchronising and triggering multivibrators.

9.5 States the methods of synchronising and triggering multivibrators.

G <u>INTEGRATED CIRCUITS</u>

10 Knows the properties and applications of a range of linear integrated circuits.

10.1 States the available range of linear inetgrated circuits and their compatability.

10.2 States the advantages of linear operational amplifiers over those with conventional transistor circuits.

10.3 Gives examples of the performance characteristics of currently-available linear integrated circuits in relation to:

(a) operational amplifier

(b) differential amplifier

(c) audio amplifier

(d) rf/if amplifier

(e) wideband amplifier

APPENDIX

T.E.C. ELECTRONICS SYSTEMS LEVEL II and III

TECHNICIAN EDUCATION COUNCIL

STANDARD UNIT

1	UNIT TITLE	Electronic Systems
2	UNIT LEVEL	II
3	UNIT VALUE	1.0 DESIGN LENGTH 60 HOURS
4	PROGRAMMES	This unit was principally devised for use in Certificate and Diploma programmes in Science validated by Programme Committees C1, C2 and C5. It may, however, be adopted for use in other TEC programmes if this is deemed appropriate. (See however, Special Note 8/4, below).
5	PRE-REQUISITE UNITS	TEC U80/684 Mathematics I and either TEC U80/682 Phsyical Science I or TEC U81/845 Phsyics I.
6	CREDITS FOR UNIT	GCE A level Electronic Systems
7	AIMS OF UNIT	1 To develop in students an understanding of the basic concept of an electronic systems as a processor with input and output signals. 2 To equip students with an understanding of simple electronic system techniques sufficient to enable them to solve simple design

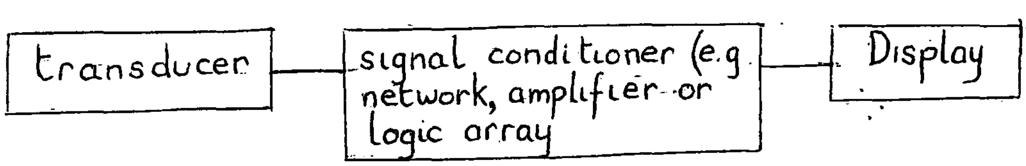
problems and construct and test the solution devised.

8 SPECIAL NOTES

1 It is expected that laboratory work will be an essential feature of the teaching method used. The entire teaching approach could be via laboratory work, but objectives 3.2, 4.3, 4.6, 4.10, 5.3 and 7.6 can only be achived in this way.

2 This unit is particularly suitable for a system-based teaching approach, with transducers (ie. amplifiers, transistors and digital logic gates) all being treated as signal processors with input(s) and output.

The underlying theme of the unit is a simple instrumentation system that could be represented thus:



3 Concurrent study of the relevant sections of TEC U81/850 Laboratory Techniques II is recommended.

4 This unit is NOT intended to provide a basis of fault-finding techniques such as might be of value to an electronics servicing technician.

ASSESSMENT ANALYSIS

This gives a very approximate analysis, by topic and types of learning, as a key to the production by a college of its assessment specification for this unit/subject.

Unit/Subject topic area(s)	Topic Area(s) as % of assessment	% of total assessment				
		Motor skills	Intellectual Skills			
			Information	Comprehension	Application	Invention
A	25		10	10	5	
B	30		10	10	10	
C	20		5	10	5	
D	25		10	10	5	
Percentage of assessment for entire unit/subject →		*	35	40	25	

* See Special Notes 8/1. It is not considered that the practical work in this unit involves Motor Skills over and above those already assessed in pre-requisite units.

10 UNIT CONTENT

The unit topic areas and the general and specific objectives are set out below. The unit topic areas are prefixed by a capital letter, the general objectives by a non-decimal number and the specific objectives by a decimal number. General objectives give teaching goals and specific objectives the means by which the student demonstrates his attainment of them. Teaching staff should design the learning process to meet the general objectives.

The objectives are not intended to be in a particular teaching sequence and do not specify teaching method, although for example many objectives (including those in the cognitive domain) might benefit from realisation in a practical situation.

All objectives should be understood to be prefixed by the words: THE EXPECTED LEARNING OUTCOME IS THAT THE STUDENT...

A TRANSDUCERS AND DISPLAYS

1 Knows the properties of simple input transducers.

1.1 Describes the characteristics of two transducers whose resistance is determined by an input (eg. thermistor, photo-resistive cell, resistance strain gauge).

1.2 Describes the characteristics of two transducers which generate an e.m.f. dependent upon their input (eg. thermocouple, moving coil microphone, piezoelectric pick-up, photovoltaic cell).

1.3 Selects, from information supplied for given simple applications, the most appropriate transducer in terms of sensitivity, linearity, response time, accuracy and frequency response (as appropriate) and justifies the selection.

2 Knows the properties of simple displays.

2.1 Describes the characteristics (eg. sensitivity, cost, response time, accuracy, physical robustness etc) of:

(a) moving coil instruments

(b) x - t plotters (chart and uv)

(c) x - y plotters

(d) Light Emitting Diode (LED) and Liquid Crystal Display (LCD).

2.2 States the advantages and disadvantages of digital displays compared with analogue displays.

2.3 Selects from information supplied an appropriate display for given, simple applications and justifies the selection.

3. Describes simple signal conditioning circuits for use with the transducers in 1.1 and 1.2.

3.1 Explain, for a resistive transducer the advantages of using a bridge circuit.

3.2 Investigates the linearity of the out-of-balance bridge current with transducer resistance change.

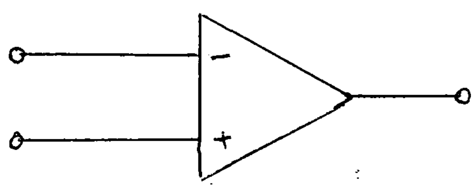
3.3 Explains, for an e.m.f. generating transducer, the advantage of using a potentiometer circuit.

3.4 Selects an appropriate circuit configuration for a given application.

B OPERATIONAL AMPLIFIER SYSTEMS

4 Understands and applies the principles of operational amplifiers.

4.1 Represents a two input, single output operational amplifier by the diagram:



explaining the terms 'inverting' and 'non-inverting'.

4.2 Recognises that, for amplification to take place, a source of additional energy is required and uses manufacturers' or distributors' literature to identify the pin connections of an Op-Amp (eg. 741 type).

4.3 Investigates experimentally how the output (V_o) varies with the difference in potential (Δv) between the two inputs for such an Op-Amp as in 4.2.

4.4 Explains both positive and negative feedback classifying simple, everyday examples.

4.5 Demonstrates how an Op-Amp (eg. 741 type) may be wired with negative feedback in both inverting and non-inverting modes, and explains how, in each case, Δv is held at a small value so the system functions as an amplifier.

4.6 Determines experimentally, the gain of the two circuits in 4.5.

4.7 States and applies formulae for the gain of the two circuits in 4.5.

4.8 Defines bandwidth and input 'resistance' of an amplifier.

4.9 Uses manufacturers' (or distributors') literature to determine the theoretical bandwidth and input resistance of the circuits in 4.5.

4.10 Designs, builds and tests (to check conformity with design requirements) an ic based amplifier having a minimum of two amplifier stages given design requirements in the form:

(a) output in-phase or out-of-phase with input

(b) gain required

(c) bandwidth required.

4.11 States examples of situations where such simple ic Op-Amp circuits may be inappropriate (ie. wideband or low noise applications).

C TRANSISTORS AS AMPLIFIERS

5 Understands the bipolar transistor as a circuit system.

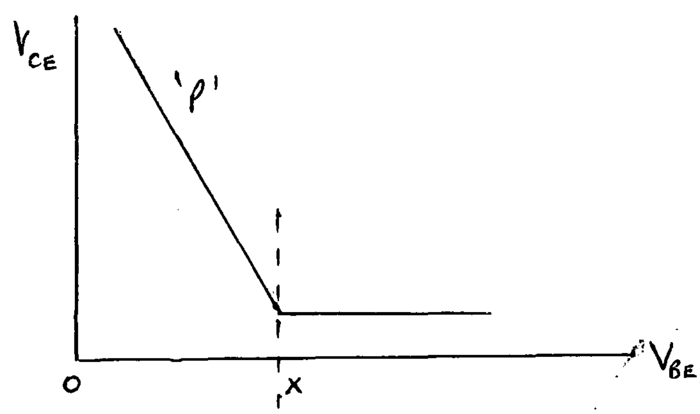
5.1 States that a bipolar transistor is a three terminal device, names the terminals and identifies them on the circuit diagram representation of such a transistor.

5.2 Indicates

(a) the correct polarity with which a power supply should be connected to the emitter/collector circuit of p-n-p and n-p-n transistors.

(b) the correct polarity with which a power supply should be connected to the base/emitter circuit of both types of bipolar transistor in order to generate a base current (I_b).

5.3 Determines experimentally how the 'output' V_{CE} varies with 'input' V_{BE}, taking a bipolar transistor with a load resistor in the collector line as a system, and displays the characteristic graphically.



5.4 Describes how the system in 5.3 may be used as an amplifier with V_{BE} varying between 0 and x, and as a switch with V_{BE} varying from 0 to a value in excess of x.

5.5 Deduces the amplification available, given a characteristic as in 5.3.

5.6 Deduces the form of the output that would be obtained if the input signal varies outside region 'P' in the characteristic shown.

D DIGITAL SIGNALS AND SYSTEMS

6 Understands the basic principles of conveying information by digital signals.

6.1 Distinguishes between common systems in terms of whether they transmit digital or analogue signals (eg. morse code, traffic lights, car speedometer, clocks, etc).

6.2 Distinguishes between serial and parallel transmission of digital signals.

6.3 Explains simply how an analogue waveform (eg. a TV signal), can be sampled and transmitted in digital form (eg. Pulse Code Modulation (PCM)).

6.4 Explains Binary Coded Decimal (BCD) representation and thus the possibility the 4-bit parallel transmission of numerical information.

7. Understands the functions of simple logic systems.

7.1 Describes a logic gate as a system that produces an output dependent upont the inputs and represents simple practical situations by means of truth tables.

7.2 Draws up truth tables for up to 3-input (single output) OR, NOR, AND, and NAND, gates simple, given, and a NOT gate.

7.3 Deduces the truth table for a simple, given system of logic gates.

7.4 Represents physical situations (eg. part of a BCD to 7 segment decoder) by a truth table.

7.5 Devises a logic circuit to meet situations as in 7.4.

7.6 Builds a circuit satisfying the conditions of 7.4 using commercially-available gates (ie. 7400 series TTL or 4000 series C-MOS gates).

TECHNICAN EDUCATION COUNCIL

STANDARD UNIT

1	UNIT TITLE	Electronic Systems
2	UNIT LEVEL	III
3	UNIT VALUE	1.0 DESIGN LENGTH 60 HOURS
4	PROGRAMMES	This unit was principally devised for use in Certificate and Diploma programmes in Science validated by Programme Committees C1, C2 and C5. It may, however, be adopted for use in other TEC programmes if this is deemed appropriate.
5	PRE-REQUISITE UNIT	TEC U81/848 Electronic Systems II
6	CREDIT FOR UNIT	GCE A Level Electronic Systems
7	AIMS OF UNIT	1 To further students' understanding of electronic systems to enable them to evaluate design problems. 2 To give students the opportunity to follow through the design, construction and testing of a system from design criteria to finished, functioning system. 3 To give students a sufficient understanding of digital systems to form a foundation for further work on micro-

processor systems.

8 SPECIAL NOTE

It is expected that laboratory work will form an essential element of the teaching method used. In particular, objectives 1.5, 3.2, 4.5, 6.1, 6.2, 6.3, 6.5, 10.1 - 10.8 can only be achieved through laboratory work.

ASSESSMENT ANALYSIS

This gives a very approximate analysis, by topic and types of learning, as a key to the production by a college of its assessment specification for this unit/subject.

Unit/Subject topic area(s)	Topic Area(s) as % of assessment	% of total assessment				
		Motor skills	Intellectual Skills			
			Information	Comprehension	Application	Invention
A	20		5	10	5	
B	15		5	5	5	
C	40		10	15	15	
D	25			5	10	10
Percentage of assessment for entire unit/subject →			20	35	35	10

10 UNIT CONTENT

The unit topic areas and the general and specific objectives are set out below. The unit topic areas are prefixed by a capital letter, the general objectives by a non-decimal number, and the specific objectives by a decimal number. General objectives give teaching goals and specific objectives the means by which the student demonstrates his attainment of them. Teaching staff should design the learning process to meet the general objectives.

The objectives are not intended to be in a particular teaching seuqnece and do not specify teaching method, although for example many objectives (including those in the cognitive domain) might benefit from realisation in a practical situation.

All objectives should be understood to be prefixed by the words: THE EXPECTED LEARNING OUTCOME IS THAT THE STUDENT....

A FETs AND BIPOLAR TRANSISTOR OSCILLATOR

1 Analyses the action of a field effect transistor (FET).

- 1.1 Compares the properties of an FET and a bipolar transistor.
- 1.2 Describes the basic construction of FETs (junction gate and insulated gate).
- 1.3 Differentiates between depletion and enhancement modes.
- 1.4 Lists the precautions required when using FETs.
- 1.5 Performs a test to obtain g_m and r_d for an FET.
- 1.6 Obtains the values of g_m and r_d from experimental data

obtained in the test in 1.5.

2 Understands the characteristic of basic sinusoidal oscillator circuits.

2.1 States that oscillations can be produced by an amplifier with positive feedback.

2.2 Explains the operation of:

(a) L-C oscillators (tuned or Hartley or Colpitts types)

(b) R-C oscillators (phase shift or wein bridge types).

2.3 States the factors that affect both the short term and long term frequency stability of oscillators.

2.4 Explains methods of improving the frequency stability of oscillators (eg. piezoelectric crystal control).

3 Understand the characteristics of nonsinusoidal oscillators.

3.1 Describes the basic circuit configuration of the different types of nonsinusoidal oscillators and switches, such as:

(a) astable

(b) monostable

(c) bistable

3.2 Constructs a simple astable multivibrator and investigates how the life of the 'states' varies as circuit components are varied.

B ANALOGUE SYSTEMS

4 Understands differential, operational amplifier circuits.

4.1 Defines common mode rejection ratio (cmrr) for an operational amplifier.

4.2 Illustrates the use of a single operational amplifier as a differential amplifier.

4.3 Calculates the gain and input impedances of a differential amplifier as in 4.2.

4.4 Demonstrates how three ic Op-Amp circuits can be wired to form a differential amplifier of high input impedance (~1M).

4.5 Constructs the circuit of 4.4 and tests its performance against predicted characteristics.

5 Compares ic operational amplifiers and discrete component amplifiers.

5.1 Contrasts Op-Amp and discrete componenet amplifiers according to the following criteria:

(a) ease of circuit design and construction

(b) noise

(c) thermal stability

(d) bandwidth

(e) input impedance

(f) output impedance

(g) gain

(h) power

5.2 Analyses a given unfamiliar situation and decides whether ic or discrete component circuitry would be most appropriate.

C DIGITAL SYSTEMS

6 Understands the various types of bistable available in integrated circuit form and appreciates their application in digital circuits.

6.1 Constructs a simple RS bistable using NAND or NOR gates and derives its truth table.

6.2 Constructs a gated RS bistable using NAND or NOR gates, derives its truth table and explains its action.

6.3 Constructs a D type bistable, derives its truth table and explains its action.

6.4 Identifies the need for a JK bistable.

6.5 Constructs a JK bistable, derives its truth table and shows how it satisfied the need of 6.4.

6.6 Identifies the need for a Master-Slave bistable circuit.

6.7 Identifies the circuit symbols for the devices in 6.1, 6.2, 6.3, and 6.5.

6.8 Describes at least one application for each of the devices in 6.1, 6.2, 6.3 and 6.5.

7 Understand the function of counting circuits.

7.1 States that a JK bistable with appropriate input connections can be used as a divide-by-two counting device.

7.2 States that counters may be synchronous or asynchronous and compares the two in terms of speed of operation, ripple through delay and dynamic hazard.

7.3 Sketches the circuit diagram of a divide-by-sixteen counter in the synchronous and asynchronous forms.

7.4 Demonstrates, using the asynchronous counter of 7.3 and a truth table including the Q and $\overline{Q}$ outputs, that it may be used to count up from 0 to 15 and down from 15 to 0.

7.5 Demonstrates (using the counter of 7.4) how, with additional gating, the count may be curtailed at any desired value.

8 Knows that bistable elements may be used to form registers and appreciates the operation and applications of these devices.

8.1 Sketches the simple logic diagram of a four-bit register showing:

(a) serial input

(b) parallel inputs

(c) clock input

(d) outputs

8.2 Describes the operation of the register in 8.1 and describes one application of the circuit.

8.3 Sketches the logic diagram of a four-bit register which incorporates the following facilities:

(a) serial input

(b) parallel inputs

(c) clock input

(d) shift mode control

(e) left and right shift capability

8.4 Describes the operation of the circuit of 8.3.

8.5 Explains how the four-bit register may be used for the storage and manipulation of digital numbers.

8.6 States that register of both types are commercially available in TL and CMOS form.

8.7 Compares the performance of TTL and CMOS registers in terms of speed and flexibility of operation.

9 Appreciates the range of storage media currently available, their limitations and application.

9.1 Defines the terms volatile and non-volatile as applied to storage media.

9.2 Defines the following terms:

(a) Random Access Memory (RAM)

(b) Read Only Memory (ROM)

(c) Programme Read Only Memory (PROM)

(d) Erasable PROM (EPROM)

(e) Dynamic Random Access Memory

9.3 List the basic requirements of any storage medium as:

(a) a system whereby the required store location is addressed

(b) a method of writing into a selected store location

(c) a method of reading data in a selected store location

(d) permanence of stored data

9.4 Sketches the block diagrams of the devices of 9.2 to show how they fulfil the requirements of 9.3.

D ASSIGNMENT

10 Devises a solution to a specified problem.

10.1 Analyses the problem to isolate the parameters involved.

10.2 Devises a solution to the problem in electronic terms.

10.3 Isolates the various electronic sub-systems that will be required to implement the solution devised.

10.4 Designs each sub-system.

10.5 Builds and test the sub-systems.

10.6 Assembles the complete system and tests it against the initial requirements.

10.7 Evaluates the solution chosen and reports on its suitability, efficiency and cost-effectiveness.

10.8 Suggests where further development work might lead to better alternative solutions.

APPENDIX

LIST OF ABBREVIATIONS USED

A.B.C.	A Basis for Choice, - F.E.U. paper 1979
A.E.B.	The Associated Examining Board
A.P.E.X.	Association of Professional, Executive, Clerical and Computer Staff
A.P.U.	Assessment of Performance Unit
A.S.E.	Association for Science Education
A.S.T.M.S.	Association of Scientific, Technical and Management Staff
B.E.C.	Business Education Council
B.I.M.	British Institute of Management
B.T.E.C.	Business and Technicians Education Council
C.D.T.	Craft, Design and Technology
C.E.E.	Certificate of Extended Education
C.E.R.I.	Centre for Educational Research and Innovation
C & G	City and Guilds of London Institute
C.P.V.E.	Certificate of Prevocational Education
C.R.O.	Cathode Ray Oscilloscope
C.S.C.S.	Centre for the Study of Comprehensive Schools, - York
C.S.E.	Certificate of Secondary Education
D.E.S.	Department of Education and Science
D.H.S.S.	Department of Health and Social Security

D.O.I.	Department of Industry
D.T.S.	Department of Trade and Industry
E.I.T.B.	Engineering Industry Training Board
E.L.C.B.	Earth Leakage Circuit Breaker
EPROM	Eraseable Programmable ROM
E.S.A.	Employment Services Agency
E.T.I.	Electronics Today International, - a journal
F.E.	Further education
FET	Field effect transistor, - a unipolar device
F.E.U.	Further Education Curriculum Review and Development Unit
G.C.E.	General Certificate of Education
G.C.S.E.	General Certificate of Secondary Education
H.M.I.	Her Majesty's Inspectorate of Schools
I.M.S.	Institute of Manpower Studies
I.C.	Integrated circuit
I.E.E.	Institute of Electrical Engineers
I.N.S.E.T.	In-service Training
I.T.	Information Technology
I.T.B.	Industrial Training Board
I.T.E.C.	Information Technology Centre
J.B.P.V.E.	Joint Board for Prevriation Education
J.M.B.	Joint Matriculation Board
K.P.U.	Knowledge, Production and Utilisation
L.A.M.P.	Less academically motivated pupils, - A.S.E. project
L-C-R	Inductance-Capacitance-Resistance Circuit
L.E.A.	Local Education Authority

LED	Light emitting diode
M.E.P.	Microelectronics Education Programme
M.F.A.	Microelectronics for All, - initiative of M.E.P.
M.S.C.	Manpower Services Commission
N.A.T.F.H.E.	National Association of Teachers in Further and Higher Education
N.F.E.R.	National Foundation for Educational Research in England and Wales
n-p-n	term to indicate polarity of a bi-polar transistor
N.T.I.	National Training Initiative
N.U.T.	National Union of Teachers
O.N.C.	Ordinary National Certificate
Op-Amp	Operational Amplifier eg. 741 type
p-n-p	term to indicate polarity of a bi-polar transistor
P.S.	Problem-Solving, - a model of innovation theory
P.S.S.C.	Physical Science Study Committee, - U.S.A.
R D & D	Research, Development and Diffusion - a model of innovation theory
ROM	Read Only Memory - permanently resident program and data
R.S.A.	Royal Society of Arts
S.A.T.R.O.	Science and Technology Regional Organisations
S-I	Social-Interaction, - a model of innovation theory
S.S.C.R.	Secondary Science Curriculum Review

T.E.C.	Technician Education Council
T.O.P.	Training Opportunities Scheme
T.S.A.	Training Services Agency
T.V.E.I.	Technical and Vocational Education Initiative
U.V.P.	Unified Vocational Preparation Scheme
v.d.u.	Visual display unit
V.E.L.A.	Versatile Laboratory Aid, - a Microprocessor Data Logger and Logic Simulator for Schools
Y.O.P.	Youth Opportunities Programme
Y.T.S.	Youth Training Scheme
W.E.E.P.	Work Experience Programme
W.J.E.C.	Welsh Joint Education Committee
555	Timer i.c. - widely used as an astable and monostable device.
741	general term for several formats of an Op-Amp i.c. - widely used as a general purpose amplifier comparator, and frequency-selective filter.

APPENDIX

Call for Papers

FOURTH INTERNATIONAL CONFERENCE ON PLASTICS IN TELECOMMUNICATIONS

London, September 1986

In 1974, 1978 and 1982 the Institute held international conferences on 'Plastics in telecommunications' in London. These were very successful with some 220 people from many countries attending. The Institute is planning to hold the fourth international conference in this series on 17-19 September 1986 at the Institution of Electrical Engineers in london.

It is intended to have both presented papers and poster sessions and authors may indicate their preferred method of presentation, the final decision however, will remain with the programme committee. The conference language will be English. Six sessions are envisaged:

1 International equipment (ie. telephone switching and transmission)
2 Cable and wire
3 Customer equipment
4 External plant (excluding cable and wire)
5 Polymers, materials and test methods
6 Field experience (problems, solutions, etc)

Papers will be welcomed on the following topics:

(a) Video services (equipment for)

(b) Optical fibre and cables

(c) Office and domestic equipment

(d) Plastics in component packaging

(e) Communicating equipment

(f) Foam Structure (in cables and equipment housings)

(g) Low fire hazards equipment

(h) Processing and assembly (novel aspects)

(i) Interconnection systems

(j) Electrically active polymers (electrets and peizoelectric materials)

(k) Recent development in batteries

(l) Plastics in recording equipment

(m) Shielding materials

(n) New or novel cable constructions

(o) Plastics in satellites

(p) New or improved materials

(q) CATV cables

(r) Thermoplastic substrates for PWBs

(s) UV and electron resists

(t) Encapsulation of components including semiconductors

Further information can be obtained from M D Shuttleworth at the Plastics and Rubber Institute, 11 Hobart Place, London, SW1W 0HL. Telephone 01-245 9555, Telex 912881 CWUKTX G marked 'Attn PRI'.

APPENDIX

Details of Electronics and other relevant journals

ELEKTOR	established 1974 95p monthly	Elektor Publishing Ltd Elektor House 10 Longport, Canterbury, Kent CT1 1PE.

Practical electronic construction projects. New products, recent developments in electronics etc. Published in Dutch, Greek, French, German, Italian, Spanish, Swedish and English.

ELECTRONICS AND COMPUTING MONTHLY	established 1982 90p	EMAP Business and Computer Publications Ltd., Scriptor Court, 115 Farringdon Road London EC1R 3AD.

ELECTRONICS AND MUSIC MAKER	established Feb 81 95p monthly	E & MM Alexander House 1 Milton Road Cambridge CB4 1UY.

Features, reviews and practical articles on electromusic including music, musicians, instruments and building projects.

ELECTRONICS AND WIRELESS WORLD	established 1911 85p monthly	Electrical-Electronic Press, Quadrant House The Quadrant, Sutton Surrey, SM2 5AS.

For designs and technicians in the radio, electronics, television and allied industries providing authoritative information on new technical developments, methods and products.
More commonly known as Wireless World.

ELECTRONICS TODAY INTERNATIONAL	established 1972 99p monthly	IPC Magazines Ltd Kings Reach Tower Standard Street London SE1 9LS

Caters for the electronics enthusiast and contains articles describing DIY projects as well as feature articles on the latest development: aimed at a fairly advanced level.

EVERYDAY ELECTRONICS AND COMPUTER PROJECTS	established 1971 90p monthly	IPC Magazines Ltd Kings Reach Tower Stanford Street London SE1 9LS

Popular and easy to build projects for the home constructor. Caters especially for newcomers with special features explaining circuit theory, components and building techniques; news of products and technological developments.

HOBBY ELECTRONICS	established 1978 90p monthly	Argus Specialist Publications 145 Charing Cross Rd London WC2 H0EE

Constructed projects for the electronics hobbyist, featur articles on electronics science and citizens band/open rad channel.

PRACTICAL ELECTRONICS	established 1964 90p monthly	IPC Magazines Ltd Westover House West Quay Road, Pool Dorset, BH15 1JG.

Contains fully detailed articles describing electronics project that amateurs can construct and deals in a popular manner wit technical developments.

SINCLAIR USER	established 1982 85p monthly (ABS Summer 1984 96,000)	ECC Publications 196-200 Balls Pond Rd London N1 4AQ

also

SINCLAIR PROJECTS SINCLAIR PROGRAMMES	6 per year at £1.25 monthly	From Summer 1984 SINCLAIR magazines from EMAP

ELECTRONICS DIGEST	established 1980 £2.25 quarterly	Argus Specialist Publications 145 Charing Cross Rd London WC2 H0EE
RADIO AND ELECTRONICS WORLD	established 1981 90p monthly	Broadcasting Limited 117a High Street, Brentwood, Essex CM14 4SG

For communication, computing and electronics enthusiasts and engineers. Latest development analysed and related to practical applications.

NEW ELECTRONICS	established 1968 fortnightly - Tuesday ABC Jan-Dec 82 27,739 Jan-Dec 83 27,099	International Thomson Publishing Limited Northwood House 93-99 Goswell Road EC1V 7AQ

Designed to keep engineers who have specifying/purchasing power abreast of the later development in the industry.

WHATS NEW IN ELECTRONICS	established 1980 monthly ABC Jan-Dec 82 30,334	Morgan-Grampian (Publishers) Ltd Morgan-Grampian House 30 Calderwood Street

	Jan-Dec 83	London SE18 6QH
	30,098	

The latest electronic products presented in seven product categories, each is further divided into product sub-groups.

ELECTRONICS MANUFACTURE AND TECHNOLOGY	established 1982 13,500 monthly Re-styled Jan 1984	Conway Kent Publishing 33 Albion Place Maidstone, Kent ME14 4D2
RADIO COMMUNICATION	established 1928 monthly ABC Jan-Dec 82 31,822	Radio Society of GB 88 Broomfield Road Chelmsford, Essex CM1 1SS

News and constructional articles of interest to radio amateurs.

RADIO CONTROL MODELS AND ELECTRONICS	established 1960 ABC Jan-June 1982 21,666	Model and Allied Publishing Limited Wolsey House Wilsey Road Hemel Hemstead Herts HP2 4SS

All that appertains to radio control of models and related electronic matters.

RADIO- ELECTRONICS	established 1980 UK 85p monthly	Gernebach Publications Inc. Zoo Park Avenue South New York
ELECTRON WEEK	established 1930	McGraw-Hill U.S.A.

APPENDIX

Reference sources of electronics journals - July 1984

NB: C L = Central Library

North Tyneside C L is situated in North Shields

TITLE	TAKEN BY	BACK COPIES AVAILABLE
ELEKTOR	North Tyneside CL	Vol I 1975-
	Newcastle CL	Vol I 1975-
ELECTRONICS AND MUSIC MAKER	North Tyneside CL	June 1981- (available at Whitley Bay Library)
ELECTRONICS AND WIRELESS WORLD	Gateshead Tech Coll	4 yrs
	Newcastle Coll Arts & Tech	5 yrs
	South Shields CL	3 yrs
	Newcastle Polytechnic	1943-
	Sunderland Polytechnic	1952-
	Sunderland CL	1981-
	Newcastle CL	1983-
	North Tyneside CL	1969-
	Gateshead CL	1960-
	Hebburn Tech Coll	1956-

ELECTRONICS TODAY INTERNATIONAL	North Tyneside CL	April 1972-
	Newcastle CL	Sept 1976-
	Hebburn Tech Coll	1976-
EVERYDAY ELECTRONICS AND COMPUTER PROJECTS	Newcastle CL	May 1983-
	North Tyneside CL	Jan 1978 (available at Whitley Bay Library)
PRACTICAL ELECTRONICS	North Tyneside CL	1967-
	Newcastle CL	1964-
	Sunderland CL	1 yr
	Gateshead Tech Coll	4 yrs
	Hebburn Tech Coll	1970-
	South Shields CL	3 yrs
RADIO AND ELECTRONICS WORLD	North Tyneside CL	Aug 1973
ELECTRONICS AND POWER	Newcastle Polytechnic	1964-
	Newcastle CL	1955
	Newcastle Coll Arts & Tech	2 yrs
	Sunderland Polytechnic	1964-
	Hebburn Tech Coll	5 yrs

Some institutions retain journals on an informal basis; at my own college (Monkwearmouth C.F.E.) relevant articles are retained for:

Electronics Today International since May 1975

Practical Electronics since October 1968

and most journals are retained for:

Hobby Electronics since October 1980

Electronics and Wireless World since January 1980

The following are not taken within the Region:

HOBBY ELECTRONICS

DIGITAL MICROELECTRONICS

ELECTRONICS AND COMPUTING MONTHLY

SINCLAIR USER

APPENDIX

U.S.A. ADDRESSES

Cambridge Development Lab:

36 Pleasant St., 100 5th Avenue,

Waltham, MA 02154 U.S.A.

Kirschner, E.

Physical Science Laboratory Experiments and Microcomputer Programmes.

Gottlieb, H.H.

Physics Laboratory Experiments and Correlated Computer Aids.

both from:

Microphys

600 Nothern Boulevard, Suite 106,

Great Neck, NY11021, U.S.A.

APPENDIX

An Assessment Scheme for Project Work Given by

Armstead, D.E.F. (1979).

Project Work in Science,

Schools Science Review Vol 60 No. 212, pp 570 - 573

Criteria for Evaluation

1. Choosing a project

(a) Has the student chosen a piece of work of appropriate standard for the course?

(b) Has the student considered safety aspects?

(c) How original is the proposed project,

i) as far as the student is concerned,

ii) on a national or international level?

(d) To what extent has the student consulted the available literature, and people expert in the field, in order to come to a decision regarding the choice of project?

(e) How enthusiastic is the student towards the work?

2. Planning the project

(a) To what extent did the student search the literature?

(b) To what extent has the student planned a logical sequence of experiments?

(c) How much thought and consideration has the student given to the ordering and preparation of material and equipment?

3. The project.

(a) How skilled is the student in manipulative operations?
(b) Does the student make proper use of the available time?
(c) How enthusiastic and determined is the student towards the project?
(d) How original and inventive is the student's practical approach?
(e) How skilful is the student regarding observation and the systematic recording of data?

4. The written account

(a) Has the student included an introduction and how relevant is it to the project?
(b) Has the student recorded experimental results properly?
(c) How skilful is the discussion and intepretation of results?
(d) How valuable is the conclusion?

5. The oral account.

(a) The student should be able to exhibit a knowledge of related work in the field.
(b) The student should be able to exhibit a knowledge and

understanding of the project.

(c) The student should be able to make an appraisal of his work and make recommendations for further work.

Educational Objectives

Choosing a Project

The student will have to exhibit an ability to evaluate and an ability to apply course material to the process of choosing a suitable project. These abilities will involve comprehension, translation, interpretation and extrapolation of various information and data.

Planning the project.

This part of the exercise will involve the student in producing a plan of campaign and a porposed set of operations.
The student will have a to exhibit a knowledge of methodology.
The student will have to evaluate knowledge and proposals and apply judgements.

The project.

The student will have to exhibit an ability to manipulate objects and materials.
The student will have to exhibit patience.
He will have to show commitment to the problem.
The student will have to exhibit a logical and systematic approach to the practical.

APPENDIX

Extract from the M.E.P. Electronics and Control Technology Domain Information File, Autumn 1984.

THREE CLEAR, GOOD REASONS WHY ELECTRONICS SHOULD APPEAR IN THE CURRICULUM OF ALL PUPILS AND WHY, FOR SOME, IT SHOULD FEATURE AS A MAJOR SUBJECT

1. Microelectronics, or New Technology, is increasingly pervasive in its influence on the world of work, leisure education, the daily organisation of our individual lives and the way in which Society is organised and controlled. Therefore, in a democratic society, all citizens should be well enough educated about the nature and capabilities of the New Technology in order to be able to intelligently influence its adoption, application and development.

2. A practical study of Microelectronics has a very great deal to offer the basic educational process at all levels of ability and age. The subject is highly motivating because it is obviously relevant. It embodies a student centred practical approach which enables personal development in a wide range of skills, aptitudes and attitudes; particularly those of communication skills within working groups. It develops the ability to think logically, to learn and to

apply knowledge to the solution of practical problems, to choose and implement a solution, to evaluate it and, if necessary, improve this solution in the light of experience.

3. If we are to survive as a reasonably successful and prosperous nation, we must be able to identifyand stimulate those special pupils, who have imaginative and creative talents, and to encourage them to become the engineers and technicians of a successful manufacturing based economy.

WE DO NOT HAVE ANY SENSIBLE CHOICE. IF EDUCATION DOES NOT PLAY ITS ROLE IN THIS PROCESS, THEN THE FUTURE DECLINE OF OUR NATION IS ASSURED.

The student will have to show an ability to think creatively and to spot and record detail.

<u>The written account</u>.

In achieving this part of the exercise the student will have to exhibit a knowledge of terminology, conventions, classifications and categories and be able to translate, interpret, extrapolate and evaluate accumulated data.

<u>The oral account</u>.

The student will have to have a detailed knowledge of the project and show a willingness to receive, ie. attend to what is being said, and a willingness to respond to questions and ideas.

He should show a satisfaction in response to discussion, questioning etc.

He should be able to express valued judgements.

APPENDIX

A.E.B. (080 Notes for Guidance) Addendum

Where a main operated project is proposed, it must conform with current Regulations, both national and local. Further, a main operated project must:

(a) be built in a metal box;

(b) Contain suitable fuses on the input and output circuits;

(c) have a neon indicator which lights when the project is plugged into the mains, ie. before any switch;

(d) have an isolating transformer;

(e) use 3 core cable for connection to the mains; this cable must have a secure cable grip (a knot will not suffice);

(f) incorporate a D.P.S.T. switch, in the primary circuit;

(g) Have circuit boards and all components firmly bolted in position;

(h) provide adequate physical and electrical separation between the mains, and the low voltage circuit.

APPENDIX

SAFETY: THE USE OF E.L.C.B.s and TRANFORMERS

Earth Leakage Circuit Breakers (E.L.C.B.s); in U.S.A. the ground fault interpreter (Lacy 1982) reported that in twenty years of use no recorded death was associated with these devices.

i) Voltage-operated, isolation type.

When a fault occurs, a proportion of the current flows through a sensor and opens the switch. The aim is to prevent exposed conduction exceeding 30v above earth potential.

ii). Residual-current operated, differential type

If a fault develops, some current will return through the earth circuit so that the current in the live and neutral conductors are no longer equal. The difference in currents induces a magnetic field in the iron ring which produces a voltage in a small coil wound on it. This voltage causes a sensor to break the circuit at a pre-determined level of leakage current, usually about 5mA in U.S.A., as prior to 1969 many circuits allowed this level of leakage. In the U.K. a nominal tripping current is 30mA as below 10mA may give rise to nuisance tripping.

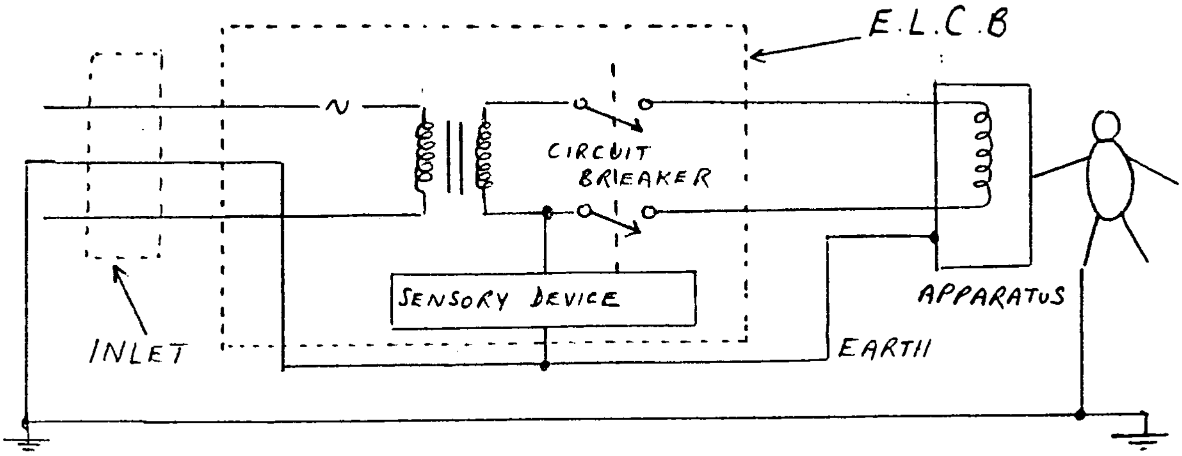
iii) Circulatory current earth monitoring.

If the earth is cut the current trips. To provide for the circulating current a pilot core is needed as shown in the diagram. Using a polarised relay/diode the system is not likely to be defeated by a pilot to earth fault.

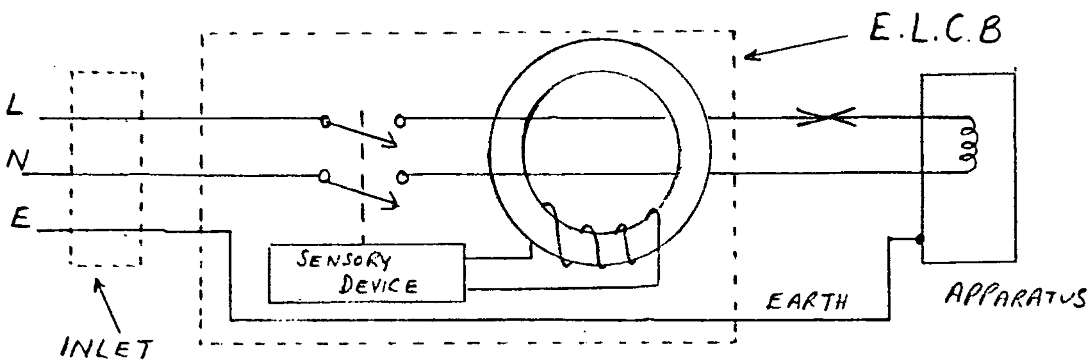
iv) Isolating transformers with a floating secondary give protection because a connection from a live point on the secondary to earth will not give a complete circuit. However, a fault in the primary also could lead to a connection to earth.

v) Isolating transformers with secondaries centre tapped to earth.
This technique is used in arduous working conditions with a 240 to 110 volt transformer allowing the use of 100v tools whilst limiting the voltage to earth to 55 volts, this voltage has not been known to cause a lethal current.

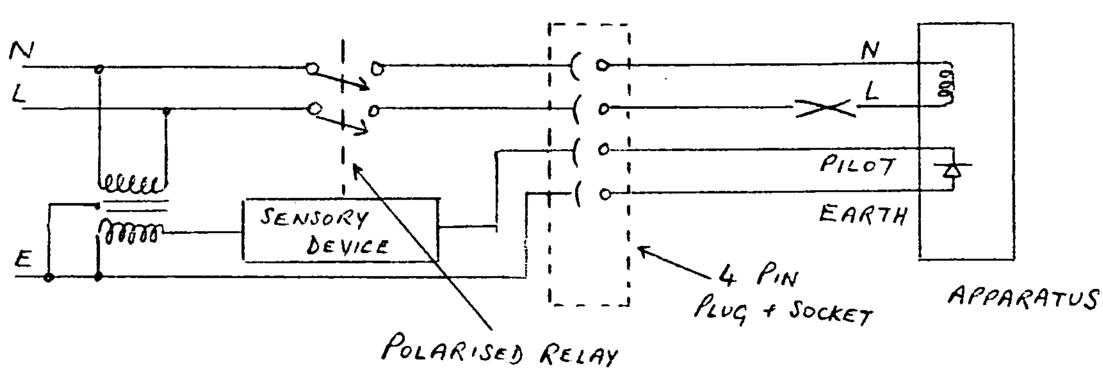
SAFETY : The use of E.L.C.Bs and Transformers



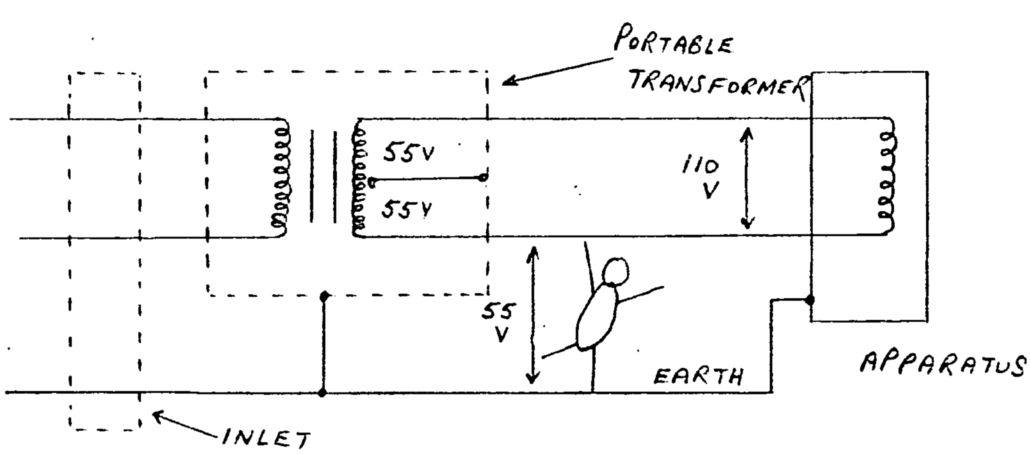
i) Voltage-operated, isolation type



ii) Residual-current operated, differential type



iii) Circulating-current earth monitoring



v) Isolating transformer with secondaries tapped to earth

TABLES SHOWING TOTAL NUMBER OF ENTRANTS FOR C.S.E. AND G.C.E. EXAMINATIONS IN ELECTRONICS FOR 1984: ALSO C.S.E. SINCE INCEPTION OF EXAMINATIONS IN ELECTRONICS

APPENDIX

LONDON AND EAST ANGLIAN EXAMINING GROUP

	84	83	82	81	80	79	78	77	76	75	74	73	72	7.
C.S.E.														
LONDON Mode 3	1226	1016	761	912	833									
E.A.E.B. Mode 3	97		92	102	98	93	114	82	71	42	15			
E.A.E.B. Mode 1	1005					689								
A.E.B. O	735													
C.A.M O	90													
C.E.E.	NA													
J.M.B. AO	0													
O.X. AO	31													
LONDON AO	675													
O & C AO	7.5													
A.E.B. 801	111													
A.E.B. 658	122													
J.M.B. E	9													

WELSH JOINT EXAMINING COMMITTEE

	84	83	82	81	80	79	78	77	76	75	74	73	72	7.
A.E.B. O	207													
A.O.	27													
A.E.B. 801	11													
A.E.B. 658	50													
J.M.B. E	9													
C.S.E. 3			121	97	79	32	40	19	22	22				

MIDLANDS EXAMINING GROUP

		84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
C.S.E.																
E.M.	1	350	429	411	306	240						Part of Eng. Science				
	3	93	65	92	102	98	93	114	82	71	42	15				
W.M.	3	295	193	231	234	218	196	173	140	77	92	69	30	22	16	17
	3	62	22								Electronics and Computer Studi					
A.E.B.	0	1280														
CAMB.	0	85														
C.E.E.																
W.M.	3	49	48	34	21	42	16	15	26							
J.M.B.	AO	160														
OXf.	AO	34														
LONDON	AO	162														
O & C	AO	15														
A.E.B.	801	106														
A.E.B.	658	139														
J.M.B.	'E'	555														

NORTHERN EXAMINING ASSOCIATION

	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
C.S.E.															
A.L.S.E.B. 3	27	44	79	70	65	40	27	30	64	49	11				
N.W.R.E.B.	214	195	168	169	153	146									
W.Y.L.R.E.B. 3	215	194	253	239	214	251	150	220	181	209	159	86	39	29	12
Y.R.E.B. 3	78	88	87	65	48	49	50	46	40	2	22				
N.R.E.B.	NA	NA	205	255	277	298	272	168							
A.E.B. O	1310														
CAMBRIDGE O	29														
C.E.E.															
A.L.S.E.B.					6			7	9						
N.W.R.E.B.															
W.Y.L.R.E.B. 3	34	32	56												
Y.R.E.B.	4	8	13	19	17	17	26	28	15	10	4				
N.R.E.B. 3			35	36	10	10									
J.M.B. AO	273														
OXf. AO	5														
LONDON AO	216														
O & C AO	7.5														
A.E.B. 801	55														
A.E.B. 658	100														
J.M.B. 'E'	1071														

APPENDIX

SOUTHERN EXAMINING GROUP

		84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
C.S.E.																
S.E.R.E.B.	3	741	699	747	583	647	703	633	615	639						
S.R.E.B.	1	664	526	386	395	256	116									
	3	0	0	0	81	45	149	229								
S.W.R.E.B.	3	276	246	244												
A.E.B.	0	1144														
CAMBRIDGE	0	113														
C.E.E.																
SOUTHERN		NA														
S.R.E.B.		NA														
J.M.B.	AO	1														
OXFORD	AO	109														
LONDON	AO	612														
O & C	AO	22.5														
A.E.B.	801	109														
A.E.B.	658	282														
J.M.B. 'E'		27														

NORTHERN IRELAND SCHOOLS EXAMINATION COUNCIL

		84	83	82	81
A.E.B.	0	153			
A.O.		36			
A.E.B.	658	60			
A.E.B.	801	0			
C.S.E.		NA	NA	15	15

a little Electronics in G.C
and C.S.E. Physics: taken b
very few

THE NUMBER OF CANDIDATES ENTERED BY INDIVIDUAL CENTRES FOR G.C.E. O, AO, A LEVEL ELECTRONICS EXAMINATIONS OR OPTION.

NOTE: Where a figure is underlined that figure was an average entry.

APPENDIX

	CENTRE / Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
	GREATER LONDON									
	I.L.E.A.									
	Division 1									
10180 C	The London Oratory School						8		8	
	Cardinal Vaughan School			9						
	Division 2									
10238 E	Parl't Hall & William Ellis VI Form	25							4	
10278 C	Pimlico School						7		3	
	Hampstead School			9						
	Maria Fidelis Convent School			9						
	St. William Collins Secondary			9						
	Division 3									
	Division 4									
	Haggeston School			9						
	Division 5									
10548 C	Stephney Green							6		
	Division 6									
10626 C	Eltham Green School	5							1	
	Division 7									
	Haberdashers Askes Hatcham Boys			9						
	Northbrook C of E Secondary			9						
10750	S.E. London School	10								
	Division 8									
10818	Geoffrey Chaucer	20								
10860	St. Veronicas R.C.	1								
10840	Warwick Park	25		9						
	Division 9									
10976	Tulse Hill	6								

EXAMINATION

APPENDIX

Should be [illegible]

Code		CENTRE	Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
		BARKING & DAGENHAM	149,200									
12121		Maysbrook Comp		10								
		Parstoes Comp.				9						
12127	C	Robert Clack Comp.		12						1		
		Warren Comp.				9						
		BARNET	296,600									
		Copthall School				9						
		East Barnet School				9						
12236	C	Grahame Park School		6						2		
		Moat Mount School				9						
		St. Marys C of E School				9						
		Wood house 6th Form College				9						
12274		Barnet Ravenscoft			5							
		BEXLEY	216,000									
		Chislehurst and Discup Grammar				9						
14133		Parklands School		3								
		St. Marys St. Josephs				9						
14105		Welling Bexley			20							
		BRENT	251,000									
12322		John Kelly Boys High			See 12349							
		BROMLEY	299,000									
14255		Beckenham Langley Park Boys			17							
		Cator Park School for Girls				9						
		Darnck Wood School				9						
14290		Kelsey Park School for Boys		5		9				5		
		Kemnal Manor School				9						
		Ramsden School for Boys				9						
14270	S	Ramsden School Joint Sixth Form				9				8		
		Ravensbourne School for Boys				9						
		Ravensbourne School for Girls				9						

APPENDIX

		EXAMINATION / CENTRE / Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
		<u>Division 10</u>									
		Battersea County Secondary			9						
		Salesian College			9						
11054		St. Walter St. John Upper School	20								
		CROYDON 316,310									
		John Newham High School			9						
		John Ruskin High School			9						
		Purley High School for Boys			9						
		Croydon High School for Girls			9						
14368	C	St. Josephs College							1		
		Stanley Technical School			9						
		EALING 280,000									
		Brentside High School			9				4		
13419	C	Cardinal Wiseman R.C. High School			9						
		ENFIELD 260,000									
		Albany School			9						
		Bishop Stepford School			9						
12538		Bullsmoor School	8								
		Chase School			9						
		Southgate School			9						
		Winchmore School			9						
		HARINGEY 227,900									
12606		Fortesmere School	8								
12608		Gladesmore School	4								
		HARROW 198,000									
12724		Harrow Weald 6th Form College	2								
		Hatch End High School			9						
		Lowlands 6th Form College			9						
12746		Rooks Heath High School	40		9						

				AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
		HARROW	198,000									
		St. Dominics 6th Form College				9						
		Stanmore 6th Form College				9						
12764		Whitmore High School		1								
		HAVERING	239,800									
12813		Abbs Cross School		20								
12819		Dury Falls School		13								
		Royal Liberty School				9						
		HILLINGDON	232,420									
		Abbotsfield School				9						
12930		Mellow Lane School		3								
12952		Town Field School		20								
12958		Vyers School		9								
		HOUNSLOW	203,900									
		Green School for Girls				9						
		Hounslow Manor				9			3			
		KINGSTON-UPON-THAMES	131,326									
14409		Hollyfield School		20								
		Southborough School				9						
14435	C	Tudor School							5		6	
		MERTON	166,000									
		Garth High School				9						
		Rutlish School				9						
		NEWHAM	212,300									
13202		Brampton Manor School		4								
13222		Little Ilford School		10								
		REDBRIDGE	226,300									
		Ilford County High School for Boys				9						
13329		Loxford High School		3								

			AEB O 080	CAM O 7060	LON AO 813	O&C AO 867	JMB AO	OXF AO 885	AEB 801	AEB 658	JMB Opt.E
	REDBRIDGE	226,300									
13305 C	Mayfield High School				9						
	RICHMOND-UPON-THAMES	160.400									
	WALTHAM FOREST	214,500									
	Chingford School				9						
	SUTTON	167,000									
	GREATER MANCHESTER										
	BOLTON	260,200									
	Bolton South College										9
	Canon Slade School						7				9
32617	Westhoughton School		11								
	BURY	175,452									
32213	Holy cross College		10								9
32219	Peel 6th Form Centre									8	
32253	Stand College		38								
	MANCHESTER	491,700									
	Arden 6th Form College		11								
	Margaret Ashton College						5				9
33763	St. Thomas More High School		20								
	Shena Simon College						4				9
	Wright Robinson High School										9
	OLDHAM	226,700									
	Grange School						2				
	Radcliffe School										9
	St. Anselm's R.C. School										9
	ROCHDALE	209,000									
	Oulder Hill Community School						11				
	Siddal Moor High School										9

			AEB O 080	CAM O 7060	LON AO 813	O&C AO 867	JMB AO	OXF AO 885	AEB 801	AEB 658	JMB Opt.E
	SALFORD	250,000									
33331	De La Salle College		12								
33305	Eccles College		20								9
33349	Pendleton College		21								
33313	Irlam High School		20								
	STOCKPORT	288,980									
33401	Bramhall High School		23								
	Cheadle Hulme High School										9
	Hazlegrove High School										9
	TAMESIDE	217,000									
	TRAFFORD	222,200									
	Altrincham Grammar School for Girls						6				9
	County Grammar School for Boys (Altrin)										9
	County Grammar School for Boys (Sale)										9
	Stretford Grammar School for Girls										9
	Urmston Grammar School for Boys										9
	WIGAN	309,200									
	St. John Rigby R.C. College										9
33711	Winstanley College		15								
	Dearney High School										9
	MERSEYSIDE										
	KNOWESLEY	184,250									
	K.Page Moss Comp. School										9
	K.Roby Comp. School						2				9
	K.Parkway Comp. School										9
	K.Prescot Comp. School		1								
	K.St. Kevins R.C. Comp. School										9
	LIVERPOOL	509,981									
	Alsop Comprehensive School										9
	Holly Lodge Comprhensive School				9						

			AEB O 080	CAM O 7060	LON AO 813	O&C AO 867	JMB AO	OXF AO 885	AEB 801	AEB 658	JMB Opt.E
	Holt Comprehensive School						2				9
	King David High						6				
	Liverpool Institute High School for Boys						3				
	New Heys Comprehensive School										9
	Quarry Bank Comprehensive School										9
	St. Hilda C.E. High School				9						9
	ST.HELENS	190, 000									
	Rainford High School						7				9
	SEFTON	300,700									
	Christ the King R.C. High School										9
	Deyes High School										9
	Manor High School										9
	Salesian High School										9
	Warwick Bolam High School										9
	WIRRAL	352,003									
	Mosslands School		48								
	Park High School										9
	Pensby Secondary School for Boys										9
	Rock Ferry High School for Boys						9				
	Cardinal Allen Grammar										9
	SOUTH YORKSHIRE										
	BARNSLEY	226,000									
	Barnsley 6th Form College						1				9
	Kirk Balk School										9
	Worsbrough High School										9
	DONCASTER	287,700									
	Don Valley High School										9
36255	McAuley R.C. School		5								
	Thorne Grammar School										9
	ROTHERHAM	252.000									
36469	Aston Comp. School		9								
36433	Kimberworth Comp. School		25								

			AEB O 080	CAM O 7060	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
36473	Swinton Comp. School		1								
	Thomas Rotherham 6th Form College						6				9
36413	Wales Comp. School		9								9
	Wickersley Comp. School										9
	SHEFFIELD	547,600									
	Carter Lodge School						5				
	Ecclesfield School										9
	High Storn school										9
36598	Jordanthorpe School						1				
	Newfield School						1				
	Notre Dame School				9						
	Rowlinson School						4				
	Silverdale School										9
36712	Stocksbridge School		12								
	TYNE AND WEAR										
	GATESHEAD	207,800									
39113	Heathfield School		25								
39139	Hookergate School		5								
	NEWCASTLE-UPON-TYNE	283,000									
39201	Benfield School				9					5	
39303	George Stephenson High School								10		
39231 C	Gosforth School				9					4	
	Kenton School				9						
39273 C	Redewood School (Pooley Road)									1	
39239 C	Redewood School				9					1	
39255	Rutherford School									1	
	St. Marys Comp. School				9						
39277	Walbottle High		8								

			AEB O 08	CAM O 70	LON AO 8	O&C AO 8	JMB AO	OXF AO 8	AEB 801	AEB 658	JMB Opt.
	NORTH TYNESIDE	199,600									
38321 C	St. Anselms R.C. High		15							1	
39323 S	Tynemouth College				9					5	
	SOUTH TYNESIDE	160,100									
39419	Springfield Comprehensive		7								
	SUNDERLAND	300,000									
39531	Farringdon School		22								9
	Houghton School										9
39537	Hylton Red House School		29		9						
39555 C	Southmoor School		9		9				2	7	
	Usworth Comp. School				9						
39575	Washington School									7	
	WEST MIDLANDS										
	BIRMINGHAM	1,006,500									
	Broadway School						6				
	Byng Kerrick Central School										9
20420	Cardinal Newmans R.C. School		1								
20061	Castle Vale School		5								
	Hardsworth Wood Boys School										9
20185	Josua Mason 6th Form		6								
	King Edward Aston Boys School						12				9
	King Edward five Ways Boys Gram. School										9
	King Edwards' Grammar School for Girls						5				
	Kings Heath School										9
	Mosely School										9
20195	Northfield School								2		
	Sheldon Heath School						13				9
20265	Turves Green Boys School		20								

		AEB O 08	CAM O 70	LON AO 8	O&C AO 8	JMB AO	OXF AO 8	AEB 801	AEB 658	JMB Opt.
	COVENTRY 310,000									
	Bingley Park School									9
	Caludon Castle Comp. School			9						9
	Cardinal Wiseman R.C. Comp. School					1				9
	Cardinal Wiseman R.C. Girls Comp. Sch.									9
20432	Coundon Court Comp. School	8								
	Erresford Grange Sch. & Comm. College									9
	Lynghall Comp. School									9
	President Kennedy's Comp. School					11				
	Tile Hill Wood Comp. School									9
	DUDLEY 300,200									
20556	Dormston School	6								
20566	Grange School	3								9
20560	High Arcal School	20								9
20570 S	King Edward VI College	25							4	9
20528	St. Gilbert Claughton School	14						3		
	Stourbridge						5			
	Summerhill School									9
20508	Thorns School and Community Centre	33								
	SANDWELL 308.900									
	Churchfields High School									9
	Menzies High School					3				9
20660 S	West Park College	25						6		9
	SOLIHULL 200,000									
20748	Solihull 6th Form College	18				4				9
	WALSALL 265,900									
	Barr Beacon School									9
	Darlaston Comp. school									9
20860	Joseph Leckie	20								
20863	Manor Farm School	10				3				

			AEB 0 080	CAM 0 7060	LON AO 813	O&C AO 867	JMB AO	OXF AO 885	AEB 801	AEB 658	JMB Opt.E
	Shire Oaks School										9
	Willenhall Comp. School										9
	Queen Mary Grammar										9
	WOLVERHAMPTON	255,400									
	Our Lady and St. Chad R.C. School						16				9
20916	Wolverhampton Colton			40							
	John Wilmot										9
	WEST YORKSHIRE										
	BRADFORD	467,000									
37101 37107	Beckfoot Grammar			26							
	Belle Vue Boys School										9
	Bingley Grammar						2				
	Buttershaw Upper School										9
	Hanson School										9
37221	Holy Family Comp. School			11							
	Nab Wood Grammar			See 37101							9
	St. Bedes Grammar School										9
	Yorkshire Martyrs Collegiate School										9
	CALDERDALE	191,292									
	Calder High School						9				9
	Crossley and Porter School										9
	Heath School										
	Highlands School				9						
	Ryburn Valley High School										9
	KIRKLEES	370,000									
	Greenhead College						2				9
	Heckmondsworth Grammar School										9
	Huddersfield New College						8				
	King James School										9

		AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.
	Shelley High School									9
	Wheelwright College					5				
	LEEDS 749,500									
	Agnes Stewart C.E. High School									9
37695	Airebrough Grammar School	10								9
	Bruntcliffe High School	3								
	City of Leeds School									9
	Morley High School									9
37681	Priesthorpe School	22								9
	Pudsey Grangefield School									9
	St. Michaels College									9
37665	Temple Moor High	6								
37777	West Leeds Boys High School	5								
	Woodkirk High School									9
	WAKEFIELD 312,000									
38195	Minsthorpe High School	20								9
	Ossett School					1				
	AVON 924,200									
50605	Bedminster Downs School	5								
50709	Hayesfield School	10								
	Mangotsfield School									9
	Monks Park School			9						
50547 C	Portway School	20		9					1	
	St. Brendans 6th Form College			9						
	Speedwell School			9						
50741	Chew Valley School	14								
	BEDFORDSHIRE 510,000									
15147 C	Harlington Upper School			9					14	
15153	Hastingsbury Upper School	1								
15118	John Bunyan Upper School & Community Ctr	12								
15247 S	Luton 6th Form College			9					10	
	Mark Rutherford Upper School			9						

			AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	Redbourne Upper School & Commmunity Ctr				9						
	St. Thomas More Upper School										9
15163	Sharnbrook Upper School		12								
15117	John Bunyan School		20								
	BERKSHIRE	695,900									
	Ashmead School				9						
	Deanfield School		2								
	Piggots School										9
	Princess Margaret Royal Free School				9						
51235	Theale Green School			5							
	Coxgreen Comp. School				9						
	BUCKINGHAMSHIRE	592,800									
52219	Burnham County Secondary School		20								
52227	Chesham High School		1								
	Dr. Challoner Grammar School				9						
	Royal Latin School				9						
	High Wycombe John Hampden							14			
	CAMBRIDGESHIRE	595,320									
	Brelton Woods Community School				9						
22131	Cambridge Parkside			10							
	Hills Road 6th Form College							6			
	Long Road 6th Form College				9						
22207	St. Peters School		22								
	Sawston Village College					7.5					
22215	St. Neots Ernulf			7							
	CHESHIRE	941,400									
40401	Frodsham High School		7								
40107	Great Sankey County High School		11								9
	Harefield County High School										9
	Henbury County High School										9

			AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	Holmes Chapel County Comp.						4				
	Kingsway County High School										9
40131 S	Priestley College		30							4	9
	Queens Park High School										9
	St. Johns Deanes College						5				9
	Stanney County Comp.										9
	The Grange County comp. School										9
	Whitby County Comp.										9
40139	Woolston County High			6							
	CLEVELAND	564,543									
	Dyke House School										9
	Eaglescliffe School				9						
	Marton College						16				9
41268	Nunthorpe School		16								
41266	South Park College		15								9
	CORNWALL	429,300									
53801	Camborne			1							
53811	Helston School			9				3			
53623	Newquay Treviglas			8							
	Redruth School				9						
	CUMBRIA	476,000									
42105	Appleby Grammar School		16								9
42313	Barrow 6th Form College		12								
	Caldew School										9
42211	Egremont Wyndham			1							
	Heversham Grammar School										9
	Keswick School										9
	Millom School						5				9
	St. Aidans School										9

		AEB O 08	CAM O 70	LON AO 8	O&C AO 8	JMB AO	OXF AO 8	AEB 801	AEB 658	JMB Opt.
42249	St. Josephs R.C. Secondary	5								
	Ulverston Victoria High School					5				
42129 C	Trinity School Carlisle								4	
	DERBYSHIRE 910,690									
	Anthony Gell School									9
23154	Clowne School	13								9
23324 C	Henry Cavendish School							2		
	Henry Fanshawe									9
	Highfield School									9
	Ilkeston School						17			
	John Port School									9
	Lady Manners School									9
	Long Eaton									
23202 C	Mortimer Wilson school							1		
23351 C	South Derby Schools Consortium							4		
23230 S	South East Derbyshire College	15							11	
	DEVON 957,000									
54118	Bideford School and Community College	16							1	
	Exmouth Community College			9						
54273	Honiton Community College	7								
54133 C	Ilfracombe School and Community College	50							3	
	Oakhampton School and Community College			9						
	Plymstock School						15			
54211 C	Queen Elizabeth School and Communit Col			9					5	
	St. James High School									
	Southway School			9						
54543	Tavistock School	20	1							
54413 C	Coombe Dean School							1		
54333	Paignton College	6								

			AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	DORSET	591,990									
55307	Blandford Upper School		4								
55147	Bournemouth St. Peters			1				6			
55377	Broadway Modern School		6								
55245	Corfe Hill School		9								
55213	Ferndown Upper			4							
	DURHAM	603,300									
	Avenue Comp. School										9
43305	Bishop Barrington Comp. School		12								
	Denehouse Comp. School										2
43417	Durham Johnston			1							
	St. Bedes R.C. Comp. School										
	St. Leonards R.C. School										9
	Shotton Hall Comp. School						10				
	Spennymoor Comp. School						6				
43121	Tanfield Comp. school		17								
	Wellfield Comp. School										9
	EAST SUSSEX	656,200									
566355	Bexhill College		16							4	
	Bishop Bell C.E. School				9						
56165	Brighton Patcham Fawcett			9							
56810 C	Cardinal Newman School									3	
56670	Helenswood School		3								
56515 C	Seaford Head School							6		2	
	Uplands Community College				9						
563102	Bruncliffe (through Morley)		3								
	ESSEX	1,493,000									
	Alec Hunter High School				9						
16619 C	Belfairs County High for Boys, Leigh			7					1		
16137 C	Beauchamps School								1		

		AEB O 08	CAM O 70	LON AO 8	O&C AO 8	JMB AO	OXF AO 8	AEB 801	AEB 658	JMB Opt.
	Billericay School			9						
16533	Bramston School	3								
	Brentwood County High School			9			7			
16405 C	Colbayns High School	32							9	
16623 O	Eastwood County High School for Boys								1	
16339 C	Great Baddow School			9				7		
16453	Harwich		6							
16519 C	Hedingham School						3			
	Hedley Walter School			9						
	Latton Bush Comp. school			9						
16823	Mark Hall Comp. School	23								
	Mayflower School			9						
16327	Moulsham High School	7								
16825	Netteswell Comp. School	8								
	Palmers College			9						
16329	Rainsford School	5								
16437 G	Royal Grammar School								16	
	St. Cedds R.C. School			9						
16305 C	St. Peters High School							3		
16627 C	Shoeburyness County High								1	
16229 S	S.E. Essex 6th Form college							10	10	
	Stewards Comp. school			9						
16453 C	Tendring High School	25						4		
16467	Thurstable School	14								
	Westcliffe High School for Boys			9						
16807	West Hatch High School	15								
	Fitz Wilmore School			9						
16111 C	Woodlands							1		
16139 C	Bromfords School							2		

		AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
44173	Malet Lambert High School, Hull	10								
44339	Waltham Toll Bar School	14								
	KENT 1,482,900									
61413	Canterbury Chaucer		6	9						
	Chatham Grammar School for Boys			9						
61555 G	Dane Court Grammar School	14						1		
61853	Folkstone School for Girls		8							
	Gravesend Grammar School for Boys			9						
61715 G	Maidstone Grammar School for Girls	12		9				4	1	
	Borden			9						
61309	Rainham Mark Grammar	3								
	St. Johns R.C. School			9						
	St. Joseph Williamson Mathematical School			9						
	Simon Langton Boys School			9						
	Sir Roger Marwood's School			9						
	Spellthorne College, Ashford			9						
661703	Swadelands School	9								
61819 C	Towers School	20							1	
61985 G	Tunbridge Wells Grammar School for Boys	10						3		
	LANCASHIRE 1,386,200									
	Nelson and Colne College					24				
46713 S	Runshaw Tertiary College								8	9
47513 G	Bacup and Rawtonstall Grmmar School								4	9
46405 C	Blackpool 6th Form & Collegiate Centre	3						8		
	Fleetwood Heskheth High School					3				9
	Greenlands High School for Girls									9
47203	Hollins High School	16								
	Lytham St. Annes High School					4				
	Mount Carmel High School					5				
	Newman College					15				
	Norden County High School			9						

			AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	S.W. HAMPSHIRE										
58203 S	Alton college									9	
58801 S	Brockenhurst College				9					9	
58203	Hardley School							7			
58641 S	Richard Taunton							30		11	9
58437 S	Queen Marys College								11		
	HEREFORD & WORCESTER	631,756									
24255 C	Dyson Perrins C.E. High School								6		
	Redditch							2			
24450	Nunnery Wood High School		1					6			
	Prince Henry's High School										9
24375	Tenbury High School		8								
	Wolverley High School										9
	HERTFORDSHIRE	967,500									
	Bushey Hall School				9						
17221	Goffs School		8								
	Hatfield School				9						
	Leventhorpe School				9						
17135	Mounbatten School		14								
	Owens School				9						
17617	St. Clement Danes School		7								
17503	Roundwood Park								5		
	HUMBERSIDE	852,400									
44143	Bilton Grange High School		8								
	Bridlington School						2				
44309	Cleethorpes Matt Humberstone			1							
	Goole Grammar School						5				9
44345	Grimsby Wintringham		3								
	Howden School, Goole						2				

			AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.F
	GLOUCESTERSHIRE	503,800									
57305	Arle School		5								
	Brockworth School				9						
57309	Cheltenham Bourneside School		20								
57017	Farmors School		1								
	St. Thomas Richs School					7.5					
57139	Saintbridge School		1								
57031	Stroud Archway			15							
57037	Stroud Marling			2							
	Newent		14								
	HAMPSHIRE	1,467,400									
	SOUTHAMPTON AREA										
58623 S	Itchen College				9						
	Merry Oak School				9					2	
	Great Saltern School				9						
58519 C	Mayfield School									2	
	MID-HAMPSHIRE										
58231 S	Barton Peveril College		16							12	
	Farnbrough 6th Form college				9						
58343	Frogmore School		30		9						
58323	Oak Farm Community School		20								
58341	Robert Mays School		18								
	Yatterley School				9						
	PORTSMOUTH AREA										
58437 C	City of Portsmouth Boys								5		
	N.W. HAMPSHIRE										
58403	Harrow Way School		4								
58707 S	Havant College		43						7	18	
	Horndean School				9						
58405	John Hanson School		10								
58123 S	Price's College				9					21	

		AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
47115 C	Pleckgate School								5	
46701	St. Marys R.C. College	20		9						9
46911	St. Michaels C.E. High School	20								
46817 S	Skelmersdale College	20							2	9
	Witton Park High School									9
47201	Accrington & Rossendale College	9								
	LEICESTERSHIRE 848,000									
	Beaumont Lays School									9
	City of Leicester School									9
	Countess Thorpe College			9						
	English Martyrs School					6				
	Gateway 6th Form College					16				9
	Guthlaxton College									9
25210 C	John Cleveland College			9			6			
25244	Leicester Mundella School	8								
25128	Rushey Mead Secondary School	14								
25160	Rutlands 6th Form College	6								
25174	Uppingham Community College	1								
	Wyggeston Collegiate					7				9
25270 S	Wyggeston & Queen Elizabeth 1st College			9					7	
	LINCOLNSHIRE 550,900									
26310	Boston Grammar		15							
26202	Bourne Grammar School	4								
	De Aston School			9						
	Kings School			9						
	King Edward VI School			9						
	Kirsteven & Sleaford High School									9
26120	Lincoln Ancaster		6							
	Lincoln Christ's Hospital School				7.5					
26148	Robert Pattinson School	20								

			AEB 0 080	CAM 0 7060	LON AO 813	O&C AO 867	JMB AO	OXF AO 885	AEB 801	AEB 658	JMB Opt.E
	Southpark High School										9
	Yarborough High School										9
	NORFOLK	704,900									
18131 C	Earlham School								4		
18327	North Walsham Girls High			6							
18331	North Walsham Paston			3							
	Oriel High School				9						
18521 C	Springwood High School		12						7		
18343	Thorpe St. Andrew, Norwich			1							
18437	Wymondham College			3							
	NORTH YORKSHIRE	673,900									
48317	Fulford School		29								9
48217	Harrogate Granby High School		13								9
	Huntington School						7				
	Northallerton Grammar School						11				
	Queen Anne Grammar School for Girls						3				
48237	St. Aidan's C.E. High School		22								9
	St. John Fisher R.C. High School										9
	South Craven High School						2				
	Scarborough 6th Form College						11				9
48181	Whitby School		8				5				
	NORTHAMPTONSHIRE	528,000									
27152 C	Chichele School								4		
27208 C	Daventry School								3		
	Kingsthorpe Upper School				9						
	Wellingborough Wren School				9						
	Western Favell Upper School				9						
	NORTHUMBERLAND	301,100									
	Astley County High School										9
	Duchesses' County High School, Alnwick							5			
49047	Haydon Bridge County High School		8								

APPENDIX	CENTRE	Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 867	JMB AO	OXF AO 885	AEB 801	AEB 658	JMB Opt.E
	NOTTINGHAMSHIRE	974,400									
	Bilborough College				9						
	Christ the King R.C. Comp. School										9
28370	Dayncroft Comp. School		11								
28330	Fairham School		20								
28354	Forests Fields 6th Form College		8								
	Joseph Whittaker Comp. School							6			9
28324	Lilley and Stone School		5								
	Matthew Holland Comp. School										9
28150	Meden School		6								9
	North Border Comp. School										9
	The Minster School										9
	Valley Comp. School, Worksop							10			
	Wilford Meadows School		18								
	Trent College				9						
	Shirebrook School				9						9
	OXFORDSHIRE	515,079									
	Churchill							1			
62455	King Alfred, Wantage					7.5					
62433	Gillott's School		2								
62453	Icknield School		6								
62437 S	King James College, Henley				9					1	
62249	Marlborough School		1								
	Matthew Arnold School				9						
62247	Wood Green		1								
	SHROPSHIRE	380,000									
29160	Croeswylan School		3								
	Idsall						7				9
29160	Lakelands School		6								
29345 S	New College, Telford		25							7	

APPENDIX	CENTRE	Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
29160	Rhyn Park School		3								9
29235	Shrewsbury 6th Form College		20								
29010	The Corbett School		5								
29155 S	Oswestry College								2	3	
	SOMERSET	342,300									
63223	Holyrood School		20								
63409	Kings of Wessex Upper School		12								
63463	Preston School		25								
	West Somerset School, Minehead							4			
	STAFFORDSHIRE	1,015,700									
30610	Belgrave Comp. School		6								
	Blythe Bridge High School				9						
30545	City of Stoke on Trent 6th Form College		20								9
30120	Cheadle High School		20								
	Edward Orme High School						2				9
30210	Leek High School		6								
	St. John Fisher R.C. High School				9						
	Sherbrook School										9
30650	Woodhouse High School		3								
	SUFFOLK	597,000									
19235	Ipswich Northgate High School			1	9						
	Kirkley High School				9						
19329	Mildenhall Upper School		9								
19335	Stoke College			1							
19125	Thomas Mills High School		3								
	SURREY	1,013,900									
	De Stafford County Sec. School				9						
64878	France Hill School		4								
	Horley Comp. School				9						
	Reigate College					7.5					

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	CENTRE	Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
	Roseberry School				9						
	St. Andrews School				9						
64200	St. Bedes School		4								
64970	St. John the Baptist R.C. Comp. School		8								
	Spelthorne College, Ashford				9						
64910 S	Strode's College									6	
	Tomlinscote School				9						
64986 S	Woking College		14							7	
64305	Yeomans Bridge School		1								
64250	Warlington		20								
	WARWICKSHIRE	468,900									
31020	Atherstone School		12								9
	King Edward VIth College					7.5					
	Myton School										9
	WEST SUSSEX	666,000									
65205	Crawley Holy Trinity			9							
	Chichester High School for Girls							6			
65123 S	Haywoods Heath School							7		12	
65428	Manhood High School & Community centre		9								
65423 C	Midhurst Grammar School				9					6	
65329	Steyning Grammar School		18								
	WILTSHIRE	523,000									
	Devizes, Dauntseys							5			
	Kingsdowne School				9						
	Westwood St, Thomas C of E School				9						
	I.O.M.										
	Ramsey Grammar School										9

APPENDIX	CENTRE	Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
	EXAMINATION										
	WALES										
	CLWYD	385,500									
68140 C	Alun School									11	
	Bryn Offa School		17								
68159 C	Rhyl High School									2	
	DYFED	316,640									
	GWENT	439,000									
68358	Duffryn Comp.		10								
	GWYNEDD	224,500									
	MID-GLAMORGAN	537,900									
	POWYS	111,500									
	Builth Wells High School										9
	SOUTH GLAMORGAN	396,900									
	Llanishen High School				9						
	St. Teilo's High School				9						
	WEST GLAMORGAN	366,900									
68818	Gowerton Comp. School		14								
	NORTHERN IRELAND										
	BELFAST	404,000									
71101	Belfast Royal Academy		6								
	St. Malachy's College				9						
71649	St. Patricks Boys Secondary School		8		9						
	N.E. AREA	333,400									
71401	Antrim Grammar School		19								
	S.E. AREA	312,900									
	St. Colmans High School, Tyrone				9						
	S. AREA	284,200									
	W. AREA	235,000									

APPENDIX F.E.	CENTRE	Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E	A.E.B.
	LONDON											
	I.L.E.A.	2,583,400										
	Hammersmith & W.London College				9							
	Brixton College				9							
10744 G	S.E. London College			11	9				17			
10662 F	Woolwich College									6		
	BARKING AND DAGENHAM											
12105 F	Barking College of Technology									2		
	BARNET											
12255	Edgeware London Open Centre			1								
	BEXLEY											
	BRENT											
12330	Kilburn Polytechnic				9				2			
12349	Willesden College of Technology		15						8	8		
	CROYDON											
	EALING											
12402	Acton Technical College		7		9							
	ENFIELD											
12530	Southgate Technical College									5		
	HARINGEY											
	HARROW											
	Harrow College of F.E.				9							
	HAVERING											
	HILLINGDON											
12956	Uxbridge Technical College		10									
	HOUNSLOW											
	KINGSTON-UPON-THAMES											
14413	Kingston College of F.E.				9					4		
	MERTON											

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Code	CENTRE / Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E	
	NEWHAM										
13244 S	West Ham College							10			
	REDBRIDGE										
13329	Waltham Forest College	10									
	RICHMOND-UPON-THAMES										
14619	Richmond-upon-Thames College								8		
	WALTHAM FOREST										
	SUTTON										
	GREATER MANCHESTER										
	BOLTON										
32129	Bolton Metropolitan College	10									
	BURY										
32217	Bury Metropolitan College of F.E.	7									
32303	Abraham Moss							6	2		
	MANCHESTER										
	OLDHAM										
	ROCHDALE										
	SALFORD										
	STOCKPORT										
	Stockport College of Technology									9	
	TAMESIDE										
33511	Tameside College of Technology	20							1		
	TRAFFORD										
33655	N. Trafford C.F.E.			9							
33621	S. Trafford C.F.E.	35									
	WIGAN										
33731	Leigh College	12									
33753	Wigan College of Technology	15							6	9	

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	CENTRE Population / EXAMINATION	AEB O 080	CAM O 7060	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	MERSEYSIDE									
	LIVERPOOL									
	Central Liverpool C.F.E.									9
	N.E. Liverpool Technical College									9
	SOUTH YORKSHIRE									
	DONCASTER									
	Doncaster Institute of H.E.									9
	ROTHERHAM									
	Rother Valley C.F.E.			9						
	SHEFFIELD									
	Richmond College									9
	Stocksbridge College									9
	TYNE AND WEAR									
	NORTH TYNESIDE									
39333	North Tyneside C.F.E.	16								
	SUNDERLAND									
39541	Monkwearmouth C.F.E.	28						10	7	
	WEST MIDLANDS									
	BIRMINGHAM									
20089	Garretts Green College	30							1	
20104	Hall Green Technical College	20								
20111	Hardsworth Technical College	40							2	
20313	Sutton Coldfield C.F.E.	40				18		16	15	
	COVENTRY									
20426	Coventry Technical College								32	
20450	Henley C.F.E.	15								
	Tile Hill C.F.E.									9
	DUDLEY									
20518	Dudley College of Technology	10						12	10	
20530	Halesowen College	12								

APPENDIX	CENTRE / Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
20562	Stowbridge Coll. of Tech. and Art	22								
	SANDWELL									
20624	Warley College of Technology	52								
	WOLVERHAMPTON									
20972	Wolverhampton C.F.E.		12							
	WEST YORKSHIRE									
	BRADFORD									
37227	Keighley Technical College	15				12				
	CALDERDALE									
	Percival Whittey C.F.E.			9						
	LEEDS									
37623	Airedale and Wharfendale C.F.E.	15								
37765	Parklane C.F.E.	65								
	WAKEFIELD									
	Wakefield District College									9
	AVON									
50755	Norton-Radstock Technical College	10								
50619	South Bristol Technical College	30								
50645	Weston Super Mare Technical College			9					9	
	BEDFORDSHIRE									
15119	Bedford College of H.E.	12								
15201	Dunstable College	35								
	BERKSHIRE									
	Bracknell C.F.E.			9						
51409	Langley C.F.E.	11								
51547	Windsor and Maidenhead C.F.E.	9								
	BUCKINGHAMSHIRE									
52201	Amersham C.F.E.	53							8	
52101	Aylesbury College	15								

APPENDIX	CENTRE / Population — EXAMINATION	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
52409	Buckingham College of H.E.	34							13	
	CAMBRIDGESHIRE									
22115	Cambridge C.F.E.		18							
22107	Cambridgeshire Coll of Arts & Tech,								9	
22211	Huntingdon Technical College	25								
	CHESHIRE									
40127	North Cheshire College							2		
	South Cheshire College			9						
	CLEVELAND									
41247	Longlands C.F.E.	20							2	
	CORNWALL									
53625	Mid Cornwall C.F.E.	17						14	13	
	CUMBRIA									
42303	Barrow-in-Furness C.F.E.	10								
42327	Kendal C.F.E.	16								
	DERBYSHIRE									
	Chesterfield College of Technology									9
23316	Derby C.F.E.	40								
	DEVON									
54285	East Devon C.F.E.	12								
54221	Exeter College			9				1		
	North Devon College			9						
54354	South Devon College of Arts & Tech.	9							8	
54359	South Devon Technical College									
	DORSET									
55117	Bournemouth and Poole C.F.E.	22							3	
55381	South Dorset Technical College	11						15		
	DURHAM									
43419	New College Durham	15								
	Peterlee Technical College			9						

APPENDIX	EXAMINATION / CENTRE Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
	EAST SUSSEX									
	Lewes Technical College			9						
56130	Brighton College of Technology								8	
	ESSEX									
16107	Basildon C.F.E.	10						4		
16317	Chelmsford C.F.E.	25								
16431	Colchester Institute of H.E.								12	
16603	Southend College of Technology		10						4	
	GLOUCESTERSHIRE									
57039	Mid-Glamorgan Tech. College	15						7		
	HAMPSHIRE									
58401	Cricklade College	9						13		
58113	Fareham Technical College	14							11	
58235	Eastleigh C.F.E.								1	
58315	Farnborough College of Technology								10	
58653	Southampton Technical College								8	
58725	South Downs C.F.E.	80							18	
	HEREFORD AND WORCESTER									
24145	Hereford Technical College	5								
24495	Worcester Technical College							11	3	
	HERTFORDSHIRE									
17119	Dacorum College	20							6	
	HUMBERSIDE									
44325	Grimsby College		8							
44363	North Lindsey College of Technology								8	
	KENT									
61417	Canterbury Kent College		4							
	Mid Kent College of F & H.E.			9						
61683	West Kent C.F.E.	6		9					5	

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	CENTRE / Population — EXAMINATION	AEB 0 080	CAM 0 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	LANCASHIRE									
47303	Burnley College of Arts & Tech.	15							1	
	LEICESTERSHIRE									
25116	Charles Keene C.F.E.	15		9						
25106	Coalville Technical College	9								
	LINCOLNSHIRE									
26308	Boston C.F.E.	18							3	
26240	Stamford C.F.E.	11								
	NORFOLK									
18521	Great Yarmouth C.F.E.	18								
18125	Norwich City College							17		
	NORTH YORKSHIRE									
48217	Harrogate C.F.E.	13								
48357	York College of Arts & Technology	60								
	NORTHAMPTONSHIRE									
	Tresham College			9						
	NORTHUMBERLAND									
	NOTTINGHAMSHIRE									
	Arnold and Carlton C.F.E.			9						
28208	Broxtowe C.F.E.	40							9	
28264	Peoples C.F.E.								4	
28378	South Nottinghamshire C.F.E.	15								
28156	North Nottinghamshire C.F.E.							12		
	OXFORDSHIRE									
62209	N.Oxfordshire Tech Coll & School of Arts	15								
62245	W.Oxfordshire Technical College	12								
	SHROPSHIRE									
	SOMERSET									
63205	Bridgewater College	15								
63459	Yeovil College	11								

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	CENTRE Population / EXAMINATION	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
	STAFFORDSHIRE									
30075	Burton upon Trent Technical College	7								
30480	Cauldon C.F.E.	20								
30290	Newcastle under Lyme C.F.E. & School Art	15							5	
	SUFFOLK									
19131	Lowestoft C.F.E.	10								
19231	Suffolk College of H & F.E.							2		
19311	West Suffolk C.F.E.							4		
	SURREY									
	Hurtwood House			9						
64720	N.E. Surrey College of Technology	12						1	3	
	WARWICKSHIRE									
31200	N.Warwickshire College of Tech & Art	10								
31310	S.Warwickshire C.F.E.	7								
	WEST SUSSEX									
651088	Worthing College of Technology	18								
	WILTSHIRE									
	WALES									
	CLWYD									
68154	Llandrillo Technical College								8	
68112	The N.E. Wales Institute	15								
	Aston College	20								
	GWENT									
68329	Cross Keys College of F.E.	20						8	5	
68375	Pontypool College	35								
68365	Newport C.F.E.	15								
	MID-GLAMORGAN									
68506	Aberdare C.F.E.	4								
68524	Bridgend College of Technology	30								
	POWYS									

APPENDIX	EXAMINATION / CENTRE Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 867	JMB AO	OXF AO 885	AEB 801	AEB 658	JMB Opt.E
	SOUTH GLAMORGAN									
68707	Barry C.F.E.	19								
	WEST GLAMORGAN									
68860	Swansea C.F.E.			9				3		
68873	West Glamorgan Institute of H.E.	8							24	
	DYFEDD									
	GWYNNED									
	NORTHERN IRELAND									
	BELFAST									
71111	Belfast College of Technology	25							49	
71447	Newton Abbey Technical College	15								
71519	Castlereagh C.F.E.	18								
	N.E. AREA									
	S.E. AREA									
71514	Bangor (annexe) C.F.E.	20								
71545	Downpatrick and Ballynahinch Tech Coll.			9					1	
71645	Dungannon and Cookstown C.F.E., E.Tyrone	12								
71514	North Downs C.F.E., Newton	5								
	S. AREA									
	W. AREA									
71825	Limavady Technical College	25								
71849	N.W. College of Technology								10	

APPENDIX MISC	EXAMINATION CENTRE Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E	801
	ESSEX SPECIAL SCHOOL										
	Chafford School			9							
	Henley on Thames Special					1					
	ADULT CENTRES										
	DORSET										
53201	Christchurch	20									
	BERKSHIRE										
62423 C	Didcot								1		
	SURREY										
64340	Farnham and Ash	18									
	MERSEYSIDE										
	Grange	9									
	NORTHAMPTONSHIRE										
27206	Grange	12									
	SALFORD										
33361	Swinton, Salford	10									
	HUMBERSIDE										
44321	Grimsby Adult Centre	24									
44138	Hull Adult Centre	36									
44360	Scunthorpe Adult Centre	16									
	ESSEX										
	Harlow			9							
	WEST MIDLANDS										
20257	Sparkhill	16									
20301	Boldmore	17									
	Leeds Comm. Ed.					8					
77889 E	H.M. Prison							1			
	Manchester Local Centre									9	
28162 E	Welbeck College								19		
	CORRESPONDENCE COLLEGE										
62317 E	Edward Greene's Tutorial Estab. Ox.							1			

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	CENTRE Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
	GREATER LONDON									
	I.L.E.A.									
10802	Allyns School				7.5					
	Colfes School			9						
10752	St. Dunstans College				7.5				5	
10287	Westminster College									
10956	South London College	5						9	1	
10148	Mander Portman Woodward Tutor									
10253	Paddington College							3		
	BARKING									
10218 C	Davies College								1	
10816	Dulwich College							10		
	BARNET									
12254	King Alfred School	30		9					1	
12202	Hendon Albany		1							
	BEXLEY									
	BRENT									
	BROMLEY									
	CROYDON									
	Royal Russell School	20								
14380	Whitgift		11							
	EALING									
	ENFIELD									
	HARINGEY									
	HARROW									
	Harrow School				7.5					
	John Lyons School				7.5					
	HAVERING									
	HILLINGDON									
	HOUNSLOW									

Population	CENTRE	AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	KINGSTON-UPON-THAMES									
	MERTON									
	NEWHAM									
	REDBRIDGE									
	RICHMOND-UPON-THAMES									
14627	St. Pauls School				7·5					
	WALTHAM FOREST									
	SUTTON									
	GREATER MANCHESTER									
	MANCHESTER									
	St. Bedes College									9
	OLDHAM									
	Hulme Grammar School for Girls					5				
	TRAFFORD									
	St. Ambrose									9
	TYNE AND WEAR									
	NEWCASTLE									
39253	Royal Grammar School				7·5					
	WEST MIDLANDS									
	COVENTRY									
	King Henry VIII School									9
	SOLIHULL									
20772	Solihull School				7·5					
	WOLVERHAMPTON									
	Tettenhall College			9						
20926	Wolverhampton Grammar School				7·5					
	WEST YORKSHIRE									
	KIRKLEES									
	Batley Grammar School	8								

APPENDIX

	CENTRE / Population \ EXAMINATION	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 8859	AEB 801	AEB 658	JMB Opt.E
	WAKEFIELD									
	Ackworth School									9
	Queen Elizabeth Grammar School									9
	BEDFORDSHIRE									
	Bedford School			9						
	Bedford Modern School					11				
	BERKSHIRE									
51201	Bradford College								7	
51241	Dowi School				7.5					
100862	Eton College	6								
51415	Licensed Vituallers	1								
51113	Wellington College				7.5					
	CUMBRIA									
	Austin Friars									9
42347	Sedbergh				7.5					
	DERBYSHIRE									
	Presentation Convent High School					3				9
	Repton School			9						
	DEVON									
54255	Exeter School						9		9	
54115	Grenville College	2								
54539	Kelly College				7.5					
	DORSET									
55309	Bryanston School				7.5					
	EAST SUUSEX									
	East Bourne College			9						
65305	Slindon School	1								
	ESSEX									
	Chigwell School				7.5					

APPENDIX	CENTRE Population	AEB O 080	CAM O 7060	LON AO 813	O&C AO 8670	JMB AO	OXF AO 885	AEB 801	AEB 658	JMB Opt.E
	GLOUCESTERSHIRE									
57319	Cheltenham College	28								
	HAMPSHIRE									
58515	Highbury College of Technology							13		
58327	Salesian College							5		
58295	Winchester College				7.5			7		
	HEREFORD AND WORCESTERSHIRE									
	Belmont Abbey			9						
24040	Bromsgrove School				7.5					
24135	Cathedral School				7.5					
	Malvern College	9								
	HERTFORDSHIRE									
	Aldenham School				7.5					
17103	Berkhampstead School				7.5					
	Haberdashers Askes School				7.5					
	Haileybury College				7.5					
17519	St. Albans School		2	9						
	St. Edmunds College				7.5					
	HUMBERSIDE									
	Pocklington School				7.5					
	KENT									
61419	Kings School				7.5					
61423	St. Edmunds School				7.5					
	Tunbridge Wells, Skinners						8			
	LANCASHIRE									
46401	Arnold School	13								
	King Edward VII School									9
	Kirkham Grammar School									9
	LEICESTERSHIRE									
	Oakham School			9						

APPENDIX

	CENTRE Population	AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	LINCOLNSHIRE									
	Stamford School			9						
	NORFOLK									
	Gresham School				7·5					
	Norwich High School for Girls	23								
	NORTH YORKSHIRE									
48301	Ampleforth College								3	
	Friends School					2				9
	NORTHAMPTONSHIRE									
27138	Oundle				7·5					
	NOTTINGHAMSHIRE									
28152	Worksop College				7·5					
	Bilborough College			9						
	OXFORDSHIRE									
62403	Abingdon School				7·5					
62356	Wolsey Hall Tutorial College								1	
	STAFFORDSHIRE									
	St. Josephs College									9
	SOMERSET									
63261	Wellington School				7·5					
	Kings College						6			
	SUFFOLK									
19241	Ipswich School				7·5				3	
	SURREY									
64325	Cranleigh School				7·5					
64390	Charterhouse				7·5					
64005	Ashtead Park, City of London		14							
64655	Epsom School				7·5					

APPENDIX

	CENTRE Population / EXAMINATION	AEB O 080	CAM O 706	LON AO 81	O&C AO 86	JMB AO	OXF AO 88	AEB 801	AEB 658	JMB Opt.E
	Ewell Castle School			9						
64355	Frensham High School				7.5					
64858	St. Georges College				7.5					
64140	St. Johns School				7.5					
64425	Reigate Grammar School				7.5					
	WEST SUSSEX									
65129	Christ's Hospital				7.5					
	WILTSHIRE									
66629	Marlborough College	10								
	GWENT									
68349	Monmouth School				7.5					

TABLE A.2 Authorities, their population and numbers of centres/studen

CODE	NAME	POPULATION	School & F.E. & Others No. of CENTRES	No. of CANDIDATES
1	Greater London I.L.E.A.	2,583,400	20+5	226+73
2	London	3,776,630	67+12	676+126
3	Greater Manchester	2,650,432	31+9+2	419+151+19
4	Merseyside	1,536,934	24+2+1	258+18+9
5	South Yorkshire	1,311,700	21+4	(175)+36
6	Tyne & Wear	1,150,500	20+2	263+61
7	West Midlands	2,646,900	43+12+2	622+368+33
8	West Yorkshire	2,089,792	34+5+1	346+125+8
9	Avon	924,200	8+3	95+58
10	Bedfordshire	510,000	9+2	114+47
11	Berkshire	695,900	6+3+1	43+29+1
12	Buckinghamshire	592,800	5+3	53+123
13	Cambridgeshire	595,320	7+3	70+52
14	Cheshire	941,400	13+2	157+11
15	Cleveland	564,543	5+1	83+22
16	Cornwall	429,300	4+1	30+44
17	Cumbria	476,000	11+2	102+26
18	Derbyshire	910,690	12+2	117+59
19	Devon	957,000	12+5	161+48
20	Dorset	591,990	5+2+1	30+51+20
21	Durham	603,300	10+2	82+24
22	East Sussex	656,200	8+2	64+17
23	Essex	1,493,000	32+4+2	338+65+18
24	Gloucestershire	503,800	9+1	74+22
25	Hampshire	1,467,400	21+6	376+164
26	Hereford and Worcester	631,756	6+1	41+26
27	Hertfordshire	967,500	8+1	70+26

TABLE A.2 (Cont)

CODE	NAME	POPULATION	School & F.E. & Others No. of CENTRES	No. of CANDIDATES
28	Humberside	852,400	8+2+3	54+16+76
29	Kent	1,482,900	16+3	182+33
30	Lancashire	1,386,200	17+1	247+16
31	Leicestershire	848,000	13+2	143+33
32	Lincolnshire	550,900	11+2	115+32
33	Norfolk	704,900	7+2	45+35
34	North Yorkshire	673,900	10+2	147+73
35	Northamptonshire	528,000	5+1+1	34+9+12
36	Northumberland	301,100	3+0	22+0
37	Nottinghamshire	974,400	15+5	174+89
38	Oxfordshire	515,079	8+2	45+27
39	Shropshire	380,000	8+0	99+0
40	Somerset	342,300	4+2	61+26
41	Staffordshire	1,015,700	9+3	95+47
42	Suffolk	597,000	5+3	32+16
43	Surrey	1,013,900	14+2+1	125+25+18
44	Warwickshire	468,900	3+2	37+17
45	West Sussex	666,000	6+1	76+18
46	Wiltshire	523,000	3+0	23+0
47	Wales	2,778,840	8+11	81+223
48	Northern Ireland	1,569,500	5+9	60+189
A	Barking	149,200	5+1	41+2
B	Barnet	296,600	7+1	58+1
C	Bexley	216,000	4	41
D	Brent	251,000	1+2	42
E	Bromley	299,000	9	107

TABLE A.2 (Cont)

CODE	NAME	POPULATION	School & F.E. & Others No. of CENTRES	No. of CANDIDATES
F	Croydon	316,310	6	46
G	Ealing	280,000	2+1	22+16
H	Enfield	260,000	6+1	53+5
I	Haringey	227,900	2	12
J	Harrow	198,000	7+1	88+9
K	Havering	239,800	3	42
L	Hillingdon	232,420	4+1	41+10
M	Hounslow	203,900	2	21
N	Kingston-upon-Thames	131,326	3+L	@0+13
O	Merton	166,000	2	18
P	Newham	212,300	2+1	14+10
Q	Redbridge	226,300	3+1	23+10
R	Richmond-upon-Thames	160,400	0+1	0+8
S	Waltham Forest	214,500	1	9
T	Sulton	167,000	0	0
	Bolton	260,000	3+1	36+10
	Bury	175,452	3+2	65+13
	Manchester	491,700	5+0+1	67+0+9
	Oldham	226,700	3+	20
	Rochdale	209,000	2+	20
	Salford	250,000	4+0+1	82+0+10
	Stockport	288,980	3+1	41+9
	Tameside	217,000	+1	+21
	Trafford	222,200	5+2	55+54
	Wigan	309,200	3+2	33+42
	Knowesley	184,250	5+	39

TABLE A.2 (Cont)

CODE	NAME	POPULATION	School & F.E. & Others No. of CENTRES	 No. of CANDIDATES
	Liverpool	509,981	8+2	74+18+9
	St. Helens	190,000	1+	16
	Sefton	300,700	5+	45
	Wirral	352,003	5	84
	Barnsley	226,000	3	28
	Doncaster	287,700	3+1	23+9
	Rotherham	251,000	6+1	77+9
	Sheffield	547,600	9+2	59+18
	Gateshead	207,800	2	30
	Newcastle	283,000	9	75
	North Tyneside	199,600	2+1	30+16
	South Tyneside	160,100	1	7
	Sunderland	300,000	6+1	121+45
	Birmingham	1,006,500	14+4+2	133+182+33
	Coventry	310,000	9+3	92+56
	Dudley	300,200	8+3	149+66
	Sandwell	308,900	3+1	61+52
	Solihull	200,00	1+1	31
	Walsall	265,900	7	78
	Wolverhampton	255,400	3	68+101
	Bradford	467,000	9+1	93+27
	Calderdale	191,292	5+1	45+9
	Kirklees	370,000	6	51
	Leeds	749,500	11+2+1	118+80+1
	Wakefield	312,000	3+1	39+9

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AEB

ELECTRONIC SYSTEMS

Advanced Level (658)

SYLLABUS, SPECIMEN PAPERS AND NOTES FOR THE GUIDANCE OF TEACHERS

The Associated Examining Board

INTRODUCTION

The syllabus for Electronic Systems at A level has been revised, and the new syllabus will be examined for the first time in 1987. This booklet sets out the new syllabus, specimen question papers, notes on the practical assessment and some syllabus topics, and specimens of the type of forms that will be used for the practical assessment. (The printed assessment forms were not ready when this booklet was prepared so that amended versions of the forms used in 1984 have been included).

The new syllabus is intended to retain the philosophy of the syllabus it replaces but to bring it up to date and to improve or remove those topics which proved to be less than satisfactory in the present scheme. There is a greater emphasis on digital systems than previously, reflecting the increasing importance of this branch of electronics. However, the syllabus is not intended to be concerned only with the hardware associated with computing, and a balance has been maintained between digital and analogue systems.

The examination in 1985 and 1986 will be based on the old syllabus. Details are available from the Board (Department A7).

In using this booklet, please check page 2 for details of any amendments (and use the page to make a note of any amendments sent out by the Board). Details of the project assessment are amended from time to time.

CONTENTS

THE ASSOCIATED EXAMINING BOARD
Wellington House, Aldershot, Hampshire. GU11 1BQ
Telephone: Aldershot (0252) 25551

AMENDMENTS

These notes were prepared in December 1984. Later editions will include information on subsequent amendments on this page.

ELECTRONIC SYSTEMS – 658

SYLLABUS – ADVANCED LEVEL Two papers, each of 3 hours, and Coursework

INTRODUCTION

The overall aim of this syllabus is to identify the general principles of systems and to exemplify them in an electronics form. A further aim is to enable the student to understand the interaction of electronic systems with modern society.

The study of general systems in terms of electronic systems has been chosen because the fundamental principles can be readily demonstrated and quantified. Modern electronic integrated circuits enable complex systems to be demonstrated simply and cheaply.

Because systems are designed for the use or benefit of man, his relevant mental and physical characteristics constitute an important aspect of the syllabus. Examples of systems in the operation of the human body and examples of the human being as part of a larger overall system are included.

Experimental work is an essential part of this syllabus and all candidates are expected to be familiar with experiments illustrating the principles in the syllabus.

AIMS

The course based on this syllabus is intended to

1. encourage candidates to identify fundamental systems principles, to appreciate the broad applicability of these systems principles and to gain experience of them by means of electronics;

2. to promote an understanding of the interaction of electronic systems with modern society;

3. to emphasise the importance of storing, processing and communicating information in the operation of a system.

ASSESSMENT OBJECTIVES

In the examination the candidate should be able to demonstrate the following abilities within the framework of the syllabus.

1. Recall and understanding of facts, principles, concepts and examples specified in the syllabus.

2. Application: the ability to apply the principles of electrical theory to familiar circuits and systems; the ability to apply systems concepts to familiar systems.

3. Application: the ability to apply appropriate knowledge to unfamiliar situations.

4. Problem solving: the ability to recognise, state, interpret and solve a problem and then to compare the solution with the original specification.

5. Analysis: the ability to apply systems principles in the analysis of a functional device or operation.

6. Analysis and computation: the ability to derive and use quantitative relationships in the analysis of circuits, systems and data.

7. Logical skill: the ability to break down a problem into a form which can be handled by electronic means and to generate the necessary algorithms for this purpose.

8. Synthesis: the ability to design a system to meet a specification.

9. Evaluation and judgement: the ability to determine alternative solutions to a problem, to select the optimum solution and to justify this selectio

10. Perceptive skill: the ability to relate practical systems or circuits to appropriate diagrams.

11. Practical skill: the ability to plan and conduct practical work involving the investigation of systems and circuits; the ability to construct neat, functional and reliable circuits.

12. Deductive skill: the ability to recognise incorrect behaviour in a system or circuit and to identify the likely causes of the fault.

13. Technological awareness: the ability to make a critical appraisal of the scope of electronics technology and its range of technological applicatio

14. Social awareness: the ability to make a critical appraisal of the interac of electronic systems with modern society.

15. The ability to present information concisely in written form and also in diagrammatic form, especially the symbols and conventions in electronic circuit diagrams.

THE EXAMINATION

The examination comprises two written papers and an assessment of practical work.

Paper 1 - 3 hours - 40% of the total marks

This paper consists of short answer questions covering the whole syllabus and assessing objectives 1, 2, 3, 5, 6, 7, 10, 12 and 15. All questions in this paper are compulsory. Questions do not carry equal marks but the question paper shows the mark allocation to enable candidates to apportion their time appropriately.

Paper 2 - 3 hours - 40% of the total marks

This paper comprises seven questions in two sections. Section A has three compulsory questions:

one question based on analysis of systems (objectives 5, 6 and 7)

one question based on system design (objective 8)

one question based on social and technological awareness (objectives 13 and 14)

Section B has four questions of which candidates are required to answer two. Each question is based on the content of a different one of the sections 2, 3, 4 and 5 of the syllabus and may test any of the objectives excluding objective 11.

Paper 3 - Practical Assessment

Candidates are expected to carry out practical work as an integral part of their course. Two components of this practical work will be internally assessed by centres and externally moderated by the Board. These two components are the candiate's laboratory notebook and a project. The assessment is based on objectives 7, 8, 10, 11, 12 and 15, and carries 20% of the marks for the examination.

The project comprises a single piece of work in electronics, selected by the candidate. It should involve planning, specification, selection of procedures, construction, evaluation and the preparation ot a report. The project carries two thirds of the marks for the practical assessment.

The laboratory notebook (log book) should contain a record of practical assignments undertaken during the year immediately preceding the examinations. The assignments, of which not less than six should be included in the submission, will normally be investigational assignments allocated to the candidate by his teacher. Such assignments are expected to provide the candidates with opportunities for selection of procedure or equipment to be used as well as the successful completion of prescribed routines.

Both the project report and the laboratory notebook will be assessed by the teacher; the project report and assessment sheet (but not the laboratory notebook) must be submitted to the Board's Moderator, and must reach the Moderator by 15th May 1987. The project report will NOT be returned.

Full details of the coursework requirements and methods of assessment are available from the Secretary General (A7) at the Board's Offices, and Centres are advised to obtain these details before assessed coursework is started.

Private candidates are also required to complete projects and laboratory assignments but they will be assessed by the Board. Such candidates will be required to attend at a pre-arranged time and place for an interview witn the Moderator. An additional fee is charged for the marking of the project by the Moderator.

GENERAL NOTES

Experimental work should be planned

(i) to provide a demonstration of general system behaviour

(ii) to introduce the correct use of instruments

(iii) to enable the candidate to identify, test and assemble components and integrated circuit subsystems.

The first of these aspects is quickly and cheaply illustrated by means of electronics and this is the reason for the combination of electronics and systems in this syllabus. Section 2 and part of Section 3 of the syllabus deal with simple systems and provide a wealth of material to serve as an introduction to the experimental aspects of the syllabus.

The units used in question papers will be those set out in the British Standards Institution publication "The Use of Units" PD5686: 1972, to which the Board's policy document "The Use of Units" 5/DM refers. Electrical and electronic circuit symbols used will be in accordance with BS3939 and text symbols used will be in accordance with BS3363. Further information on these conventions, and on the symbols and conventions which will be used in logic diagrams, is included in "Notes for the Guidance of Teachers". [Section 1]

Candidates are not assumed to have taken an O level course in Physics or Electronics prior to their work on this syllabus, but such a background would be advantageous to the candidate. A background of O level Mathematics is assumed. Some additional mathematical topics are required and these should be introduced with the relevant syllabus topics if the candidate is not taking a course in A level Mathematics. In particular, the level of treatment of calculus and graphical work may need to be beyond what is normally included in an O level syllabus. Electronic Systems may be taken at the same sitting as any other AEB subject except O level Electronics.

Electronic calculators, mathematical tables and slide rules, as specified in the Board's Regulations, may be used in all examination papers.

All teachers preparing candidates for this syllabus and all private candidates should obtain a copy of "Notes for the Guidance of Teachers" by applying to The Secretary General (A7) at the Board's Offices. (Figures in square brackets, e.g. [2.1] , in the syllabus are references to specific sections in "Notes for the Guidance of Teachers".)

1. GENERAL SYSTEMS [3.1]

A system is any organised·assembly of components and procedures which has a defined function and a means of control. There will thus always be identifiable inputs and identifiable outputs, and most systems have other characteristics which are general in nature, notably feedback paths and decision-making facilities.

A system may be biological, mechanical, electrical or electronic; this list is not exhaustive and some employ a combination of media. It may be concerned with information, or materials. The main function of a system may be correlating, decision-making or producing. It may be concerned with transport, communication or energy transfer.

There are general features which characterise all systems, and it is the purpose of this section of the syllabus to specify the general features that may be examined and the type of context within which examination questions will be asked.

It is not the intention that this section should be taught as a separate element of the course, and the majority of questions set will integrate these concepts into specific systems which demonstrate them.

1.1 Features of a system:

defined function; output; inputs of information and materials; control inputs; power inputs; feedback-control inputs	Candidates should be able to identify these features in a wide variety of systems.

1.2 Processing:

	The need for an element to process inputs to generate the required output. Processing may be concerned **with information or with power or with materials.**
Transfer characteristics	The defined relationship between input and output. Candidates should be aware of the various kinds of transfer characteristics and possible ways of expressing the characteristic.
Information processes: comparison (equivalence); magnitude determination (e.g. counting); arithmetic processes (e.g. addition); decision making	The processing element, whether analogue or digital, will have to undertake one or more of these processes. It is not always possible to classify processes precisely into these four categories.

Memory	Candidates should appreciate that all systems have memory.
1.3 Programming and Memory:	Candidates should appreciate that a system can be programmed and that this program will modify the transfer function of the system. This program is stored in memory.

1.4 Communication:

The transmission of information between the system components

1.5 Control:

Feedback	Feedback is a special example of a control input to a system.
Decomposition of a system into sub-systems	The candidates should understand that, for example, a thermistor can be treated as a system or as a sub-system of a thermostatic system, which in turn can be a sub-system of a heating system.

1.6 Energy inputs:

Principle of conservation of energy	Candidates should understand that all systems require a source of energy and do work.
Impossibility of perpetual motion	

2. ELECTRONIC SUB-SYSTEMS, CONCEPTS AND COMPONENTS

2.1 Background Concepts:

The following items pervade all aspects of the syllabus and should be included at the appropriate points. The depth of treatment is that required to form a basis for the work on the topics specified.

Electric charge, current, voltage, resistance, capacitance, inductance, reactance, impedance, resonance power. Ohm's law, Kirchhoff's laws (as simple practical concepts rather than complex mathematical exercises)
Resistors, capacitors, transformers

2.2 Waveforms:

Sinusoidal waveforms	Frequency, period, peak, mean and r.m.s. values, phase.

Other waveforms	Familiarity with rectangular, square, step, exponential and linear ramp waveforms is expected.
Characteristics of waveforms	Rise time, fall time, pulse repetition rate.
Combination of waveforms	Implications of Fourier's theorem, demonstrated graphically.

2.3 Amplifiers:

The integrated circuit operational amplifier should be used to support the material in this section.

The amplifier as a system block	Power requirement - single and dual voltage supplies. Appreciation of low efficiency of amplifier system. Efficiency always sacrificed for quality.
Amplifier characteristics	Linear region and saturation. Saturation level determined by voltage supplies.
Inverting and non-inverting amplifiers	
Directly coupled amplifiers [3.2]	Used for zero frequency operation.
Characteristics of the ideal voltage amplifier	Including features of the differential amplifier system.
Voltage feedback [3.3]	Derivation of $A' = \frac{A}{1 - \beta A}$ (A' = closed loop gain, A = open loop gain)
Negative and positive voltage feedback	Features of negative voltage feedback and its role in amplifier design. Positive voltage feedback for oscillators and switching circuits.
The current amplifier	
Decibel scale [3.4]	Use restricted to frequency response.
Frequency Response: features of first-order response to include 3 dB point roll-off of 20 dB/decade phase change $\leqslant \pi/2$ phase change at breakpoint = $\pi/4$	Simple low-pass and high pass RC networks. Candidates should be able to sketch or interpret a graphical representation of gain and phase dependence on frequency for a low-pass first-order frequency response [3.5]. Candidates should be able to explain why this form of response is preferred for amplifiers, particularly those having feedback applied.
Bandwidth	Effect of negative voltage feedback on bandwidth. Relationship between bandwidth f_o and rise time t_R for an oscilloscope amplifier: $t_R f_o = 0.35$ [3.6].

2.4 Diodes:

The characteristic of a silicon junction diode	Candidates should know that for conduction there is a forward voltage drop of 0.2 V for germanium and 0.7 V for silicon and that there is a capacitance at the junction which is voltage dependent.
Zener diode characteristic	Slope resistance. Use with constant current source for voltage reference. Simple Zener stabilised voltage supply.

2.5 The Operational Amplifier:

Throughout this section the operational amplifier is assumed to be ideal.

Inverting configuration (including summing amplifier)	Virtual earth concept [3.7] **input resista** Derivation and use of gain equation for single and multiple inputs.
Non-inverting configuration	Derivation and use of gain equation. Candidates should understand that the input resistance is the input resistance of the operational amplifier.
Transfer characteristics	Candidates should be aware that the transfer characteristic is linear below saturation limits.
Voltage follower (unity gain amplifier)	Used as current amplifier and as a system with a high input resistance and low output resistance.
Difference amplifier (Subtracting amplifier)	Derivation and use of gain equation.
Integrator	Derivation and use of $V_o = -\frac{1}{RC} \int V_{in}\, dt$
Comparator	
Regenerative comparator (Schmitt trigger)	Including calculation of switching thresholds.
Astable multivibrator	Using regenerative comparator. Candidates are expected to be able to explain the operation of this circuit, draw appropriate waveforms, and calculate pulse-repetition rates.

2.6 Transistor Circuits:

This section is based on the silicon bipolar junction transistor and, apart from the emitter follower section specified below, is limited to the common emitter configuration.

Transistor behaviour in terms of characteristics	Candidates should be able to sketch and interpret characteristics but questions will not be set on the determination of characteristics.
Biasing network for transistor amplifier stage	Candidates will be expected to perform calculations on simple biasing networks. Candidates should (i) neglect leakage currents (ii) assume $V_{BE} = 0.7$ V (iii) know that $h_{FE} = \frac{I_C}{I_B}$
Use of transistor as linear amplifier	Qualitative treatment only.
Use of transistor as a switch	Candidates will be expected to perform calculations on simple transistor switching circuits including the effect of loading.
Emitter follower network	Limited to d.c. conditions only, including input and output currents. Use with Zener diodes in stabilised power supplies.

2.7 Timing Circuits:

The charge and discharge of a capacitor through a resistor	Candidates should know and be able to use the equations $v_C = V\ (1 - e^{\frac{-t}{RC}})$ $v_C = V\ e^{\frac{-t}{RC}}$ but questions on their derivation will not be set.
Monostable and Astable	Treated as functional blocks (See also Section 2.5
Integrated circuit timers	Principles of operation of the 555 type of timer [3.13]
Quality of components necessary for precision timing	
Analogue timing methods compared with digital methods	
The quartz crystal as a frequency standard	Candidates should appreciate the selectivity and stability of a quartz crystal.

3. INFORMATION

Information is the encodement in physical form of knowledge that is to be stored or processed.

3.1 Information representation:

The need for a carrier, a code, a transducer to encode the information and a transducer to decode the information

The characteristics of digital signals	A signal with a finite number of discrete states, arranged in groups wherever it is required to enhance the information content. Compatibility with electronic circuits. Low susceptibility to distortion. Not directly compatible with human senses. Easily processed. Need for very high speed of operation in complex processes. Resolution dependent on number of bits.
The characteristics of analogue signals	A signal that may have a continuous variation of a property (such as voltage or frequency). Easily compatible with human senses. High susceptibility to distortion. Resolution dependent on sensitivity to signal magnitude.
Signal patterns. Letters, figures and pictures.	The pattern-recognition ability of humans compared with the serial processing (scanning) of electronic systems.
Identification of analogue and digital signals	Candidates should be able to state examples of digital and analogue signals in both electronic and non-electronic systems and to identify the nature of the signal in any system which is within the common experience of an A level candidate (e.g. roads and traffic, domestic equipment, common sports).

3.2 The Human Information System

Human Sensors	Humans receive and interpret large quantities of information through sen of sight, hearing, touch, taste and smell, in analogue form. Candidates are expected to understand the import of this in the interaction between ma and machine, and to understand that t nervous system which accepts the sens stimuli is fundamentally a digital information system

3.3 Information in digital form:

Binary representation	Conversion between decimal and binary representations.
Physical representation of binary numbers: use of any two-state variable; use of discrete voltage levels in electronic systems	
Bit, byte, word	
Hex (hexadecimal) representation	The advantages of hex compared with binary. Conversion between hex, decimal and binary.
Parallel and serial representation	
Coding and decoding of information; concept of parity bit and sign bit	Candidates should understand that a bit stream must be interpreted in terms of the code being used. Particular reference should be made to representation as an integer, an ASCII Code or a floating point number, but candidates are not expected to remember the ASCII code or a particular floating point representation.

3.4 Translation of information:

Analogue to digital (A to D) and digital to analogue (D to A) conversion. Time quantisation: sampling rate and Nyquist criterion [3.8] Amplitude quantisation: resolution.	Treated as a functional block only: circuits are not required. Candidates should understand that the sampling frequency should be at least twice the frequency of the highest component present, to avoid distortion.

3.5 Processing analogue information:

Candidates are expected to recognise that the processes discussed in Sections 2.3, 4.4 and 4.5 are among the procedures for dealing with analogue information

3.6 Manipulating digital information:

Logic gates: NOT; AND; OR; NAND; NOR; Combinational logic circuits including the half adder, adder, comparator and data selector	The truth table for each of these gates should be known. Candidates should be able to: express the behaviour of a particular physical situation in the form of a truth table design a logic system to fulfil a truth table derive a logic system expressed entirely by NAND functions. Minimisation is not required.
Use of Boolean algebra notation	Manipulation of Boolean expressions will not be examined.
Sequential logic-systems	As systems whose outputs are determined by past and present input conditions. Cross coupled gates used as a set-reset bistable.
The triggered bistable	The functional characteristic of D-type and J-K type bistables. Treated as a functional block only.
Shift registers and counters	Serial and parallel data aquisition. Up and down ripple-counters including use of reset at any specific count. Synthesis of registers and counters fro bistables including use of set and rese
The data latch	

3.7 Storage and Retrieval of Information:

Analogue systems:	
disc;	Storage and retrieval of stereo audio signals. Nature and purpose of equalisation in recording system. Principles of operation of electro-magnetic and piezo-electric pick up heads.
magnetic tape;	Principles of operation of recording-head for record and play-back. Maximum permissible size of tape head gap for signals of a given recorded wavelength.
storage of video signals	Limited to the principles specified above but including comparison of serial access in electronic systems with parallel access in photographic systems.

Digital systems: meaning and use of RAM, ROM, PROM and EPROM	
characteristics of digital memories	Mode of access, access time, volatility, capacity, physical size, power requirement.
Comparison between magnetic disc and magnetic tape stores	
3.8 Processing Digital Information; the Microprocessor:	
Central Processor	To include arithmetic logic unit, accumulator, instruction register and program counter.
Sequential behaviour of processor	Qualitative treatment of the processor as a clocked logic block. Clock, machine and instruction cycles. Qualitative understanding of processes occurring during "fetch" and "execute" parts of instruction cycle.
Bus structure	Data bus, address bus, control bus, tri-state outputs.
Address decoding	Including the concept of a memory map and the need for address decoding.
Memory	
Access	Serial and parallel access for inputs and outputs to the computer system. The relative merits of serial and parallel access. Knowledge of specific devices or circuits is not required.
Block representation of a bus organised microprocessor system	
Languages	Need for a language. Relative merits and form of machine code, assembly language and high-level language. Function of assembler and compiler. Specific knowledge of any language is not required.
Peripherals	Limited to those peripherals included elsewhere in this syllabus.
Interfaces	The need for interfaces in using external devices. Design of interfaces is limited to the use of functional blocks specified elsewhere in this syllabus

3.9 Information display:

Visual display systems:
cathode ray
light emitting diode
liquid crystal

Candidates should be able to describe, compare and contrast these displays in terms of their power consumption, physical size, visibility and versatility.

Printers

Candidates should be able to discuss the relative merits of printers and the visual display included above.

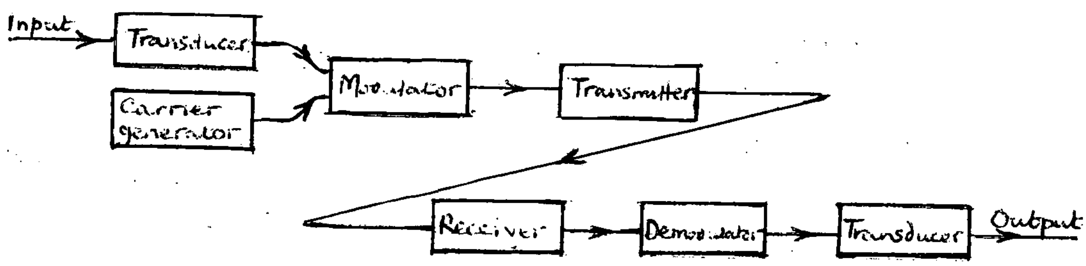
The seven segment configuration for numeric display

Including the concept of multiplexing in a multi-digit display and the inherent advantages of this technique in terms of power consumption and reduction in number of connections required.

4. COMMUNICATION SYSTEMS

4.1 Principles of Communication Systems

General block diagram of a Communications system.



Candidates should be able to identify system elements in: direct audio communication; direct visual communication; radiative systems; cable systems; fibre-optic systems.

Need for a carrier and a transmisssion medium; concept of modulation

Candidates should be aware that the information is contained in the frequenc and amplitude variations of the modulati signal.

Wave characteristics

Wavelength x *frequency* = *velocity*
Amplitude and Phase. Concept that a comp wave is made up of sinusoids.

Distortion and Noise

Distinction between distortion and noise

Mathematical treatments of noise are not required.

Bandwidth and channel width

Bandwidth of message signal. Effects in terms of bandwidth of modulating the mes signal on the carrier.
Dependence of information capacity of a channel on its bandwidth.

Filters

Low-pass and band-pass filters treated as functional blocks.

Channel selection and multiplexing [3.10]	Principle of multiplexing as a means by which a number of channels may be transmitted in a single medium; demultiplexing as a means of selecting individual channels.
Frequency division multiplex Time division multiplex Use of simple LC circuits for channel selection	Including use of $f = \frac{1}{2\pi\sqrt{LC}}$

4.2 Audio Communication

Response of the ear	Frequency and intensity responses. Candidates should realise that the information content depends on both frequency and amplitude but not phase.
Response of the receptor - brain system	The ability to select a particular sound source from a noisy environment. Effects of tiredness, alcohol, etc.
Speech recognition	Distinction between message component and other information given in speech, such as mood. Redundancy of information in language.

4.3 Visual Communication

Response of the eye	Frequency (colour) and intensity (sensitivity) responses. Persistence of vision.
Colour	Colour vision in terms of three broad spectral responses. Relative effects of colour and contrast on perception of detail. Colour addition as used in colour television.
Vision	The brain's response to complex visual images, field of view, flicker, and optical resolving power.

4.4 Amplitude Modulation (AM)

Nature of amplitude modulation	Time waveforms. Modulation index (depth of modulation). The production of two sidebands of frequency differing from the carrier frequency by an amount equal to the modulating frequency. Mathematical proof not required.
Bandwidth requirements of an AM signal	
Frequency-division-multiplex Sideband suppression.	Concept of channel allocation

Limitations of AM	
Noise	Including impulsive interference
Fading	
Quality	Dependence of quality on bandwidth
Demodulation (detection) of AM	
Principles of diode demodulator	To include choice of filtering component:
Superheterodyne principle Advantage of its use	Mixing of the received radio frequency s: with a signal from a local oscillator to produce a fixed intermediate frequency. Candidates are expected to realise that this is the same process as modulation.

4.5 Frequency Modulation (FM) [3.8]

Nature of FM	Candidates should be able to identify hov the amplitude and frequency of a modulati signal are encoded on a carrier by frequency modulation. Candidates should able to represent this in diagrammatic f(
The spectrum of an FM radio signal.	Qualitative treatment only.
Bandwidth requirements of an FM signal	Need to limit the number of transmitted sidebands. Relevance to quality and available channel space.
Comparison between FM and AM	
Noise	Including amplifier clipping to eliminat(impulsive noise
Quality	Comparison with AM
Cost and complexity	In terms of both circuitry and the syster as a whole.
Demodulation of FM	The principle of using pulse averaging.

4.6 Digital Communication Techniques

Sampling	Including quantisation distortion. See Section 3.4 of the syllabus.
Pulse Code Modulation (PCM)	
Time division multiplex	Use of interleaved samples to produce multilink system using one channel.
Bit rate	Effect of system bit rate on number of possible channels and on signal quality.
Use of non linear quantisation scale (companding)	Use to produce better quality at low levels of signal.

4.7 Television Systems

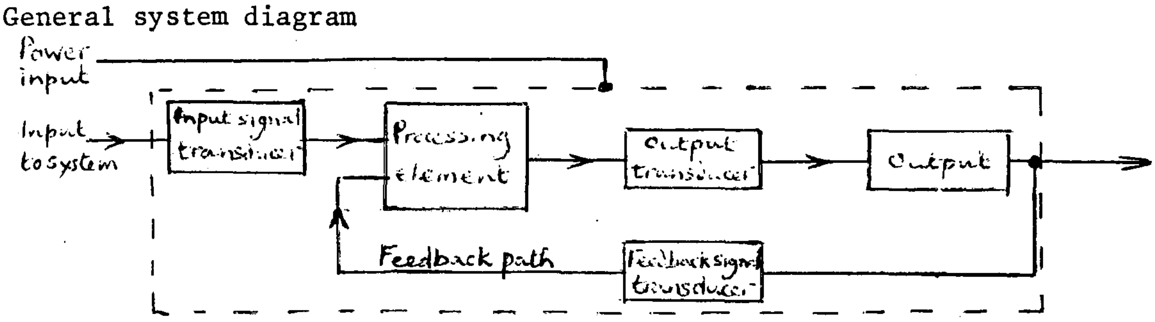
Conversion of picture information into serial electronic signals	Principle of raster scanning. Details of camera system not required.
Factors affecting picture quality	Visual resolution Picture element size Number of lines Field repetition rate Interlacing
Synchronisation of display	The need for both line and field synchronisation.
Picture transmission systems	Composite nature of tansmitted signals. Calculation of Bandwidth requirements. Comparison of broadcast television and slow scan systems. Principles of teletext.
Colour television systems	Separate transmission of brightness signals and colour difference signals to achieve compatibility with black and white television. Relative bandwidths required for brightness and colour information.
Block diagram of colour television receiver.	

5. CONTROL SYSTEMS

This section is concerned with control systems in which feedback is employed; it includes systems where pare or all of the system is non-electronic.

5.1 The Generalised Control System

General system diagram



Linking each part of the system there must be a communication path. The feedback path is a particular combination of communication paths. In any particular system the elements may not be separately distinguishable in th form shown in this diagram.

Feedback Positive and negative feedback including their effects.	Candidates should understand that feedbac is the process where a signal dependent o the actual output state influences the sy behaviour. Candidates will be expected t be able to identify the source of the fee signal, its nature and effect in general and specifically in the particular system detailed in this syllabus.
Behaviour in specific systems:-	
Servomechanisms	Position control
Thermostatic temperature control	
Public address systems	Acoustic feedback
Mechanical speed governor	

5.2 The Human Being as a Controller

Characteristics of human sensors	
Hearing	Frequency and intensity responses. Stereophonic hearing. The physiology of ear is not required.
Sight	Frequency (colour) and intensity (sensitivity) responses. Persistence of vision. The physiology of the eye is not required.

Characteristics of the human being as an information processor	Ability to discriminate between required and non-required information received as parallel inputs from the senses.
Body control processes	
Voluntary and involuntary control	Simple description of sub-systems within the human body that perform control tasks. Sub-sections to include, body temperature control, voice control, iris control, touch and reflex actions.
Human Being as the feedback path in a system	
Human Control Actions	Candidates may be required to analyse simple control tasks such as inserting a key in a lock. Human actions in a learned sequence e.g. walking, dressing. Comparison with complex tasks involving interacting external influences such as driving a car or playing a team game. Use of memory; human ability for judgement and intuition; role played by experience in determining human action.
Comparism between human and machine controlled systems; robotics	Candidates will be expected to show an understanding of the capabilities and limitations of programmable systems compared with the human being, with particular reference to relative memory capacity, and reliability. Candidates should appreciate that machines can only be used for processes that are predictable.

5.3 Proportional Control Servomechanisms

The ideal proportional control servomechanism: demanded-position potentiometer. slave potentiometer controlled by a motor, subtractor, and amplifier to drive the motor.	Response of this system without friction or inertia. Effect on response of attenuating the feedback signal.
Characteristics of a real system: inertia	
friction	Dead band resulting from friction and its dependence on amplifier gain.
frictional damping	Including disadvantages
velocity damping	Qualitative treatment only
response to a step input	Qualitative treatment of under-damped, critically damped and over damped systems

5.4	<u>Non-linear control systems</u>	
	On/off control systems: Hysteresis	To include thermostatic control
	Stepping control systems: Characteristics of a stepper-motor driven system [3.12]	
	Computer controlled systems	Candidates will be expected to describe the behaviour of a given system.
5.5	<u>Transducers</u>	Treated as a System component that converts a signal from one form into another, one of these forms being electrical. Candidates should be familiar with common input and output devices used in thermal, acoustic, optical and position dependent systems. construction and physical characteristics of transducers will not be examined, but questions may be set which specify transducer transfer characteristics in connection with the design of appropriate electronic systems employing those transducers.
5.6	<u>Microprocessors in Control</u>	Candidates are expected to be able to apply their knowledge of microprocessors as specified in Section 3 to control systems in order to be able to answer qualitati questions on microprocessor control.

THE ASSOCIATED EXAMINING BOARD

for the General Certificate of Education

Advanced Level

ELECTRONIC SYSTEMS

Paper 1 **658/1**

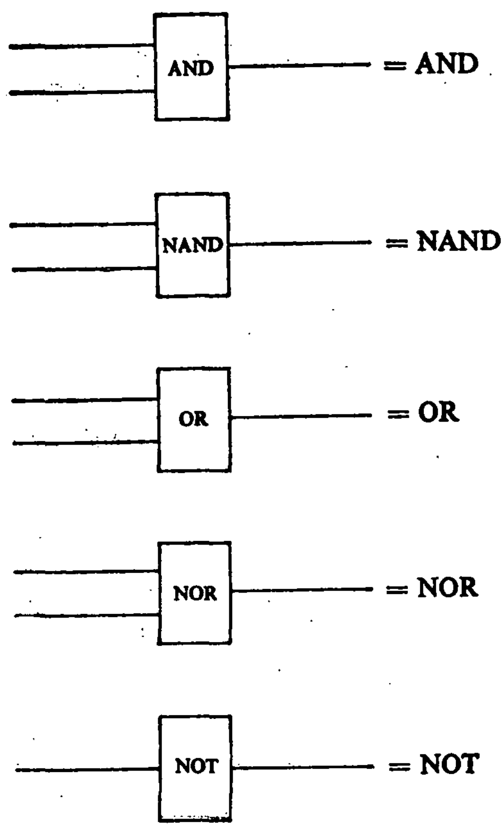
SPECIMEN PAPER

3 hours allowed

Answer ALL *questions*

This paper carries 40% of the total marks for the examination.

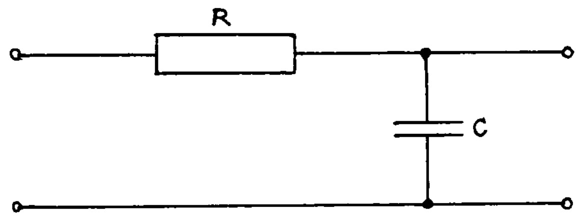
The marks in brackets at the end of each question or part of a question are the marks allocated to that question or part of a question.



Assume that 0.7 V exists across a forward biased silicon diode and across the base-emitter junction of a transistor which is biased on.

[*Turn over*

1



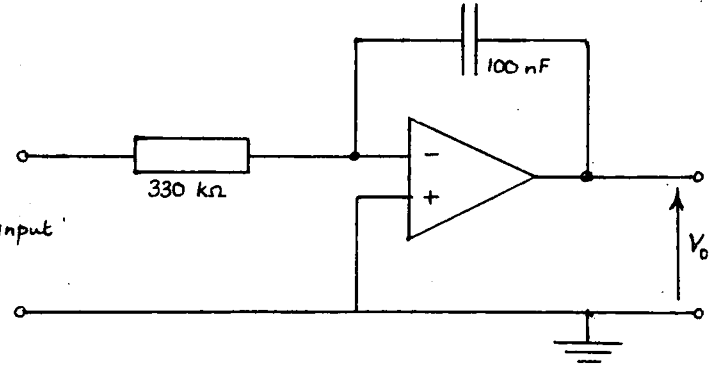
(a) Explain briefly why the circuit above is termed a *low-pass network*. (4 marks)

(b) The bandwidth to the 3 dB point of the low-pass network in the circuit above is given as $\frac{1}{2\pi RC}$. What does this mean? (3 marks)

(c) The Y-amplifier of an oscilloscope has a bandwidth of 10 MHz. Assuming that this bandwidth is determined by the network shown above at the input to the amplifier, calculate the rise time recorded by the oscilloscope when an ideal step is applied at the input. (2 marks)

2 An amplifier with an open-loop voltage gain of 1000 is used in an inverting amplifier system with negative voltage-feedback. The feedback fraction β is 20%. What input signal is required for an output of 2.0 V? (3 marks)

3 The operational integrator shown below has its input switched from earth to −10 V. Determine the rate of rise $\left(\frac{dV_0}{dt}\right)$ of the output voltage. (3 marks)



If the feedback capacitor is discharged at the end of every half-cycle of a 50 Hz signal calculate the maximum output voltage from the integrator. (2 marks)

4 Each of the logic circuits fig. 1 and fig. 2 shown below functions as a set-reset bistable. Determine, stating your reasoning,

(a) which input in each case is the SET input

(b) whether SET is achieved in each case by a transition from logic 1 to logic 0 or vice versa. (8 marks)

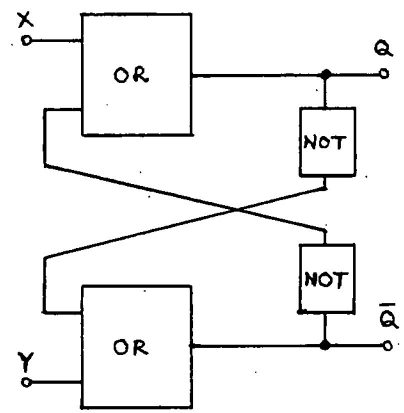


fig. 1

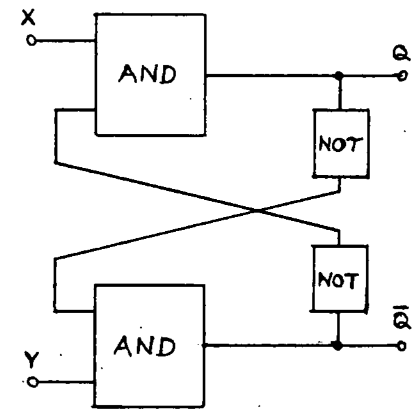
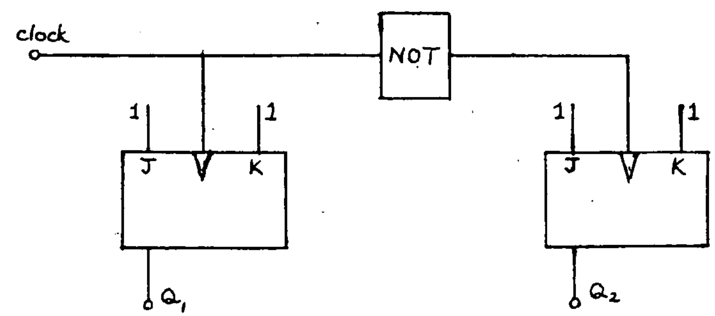
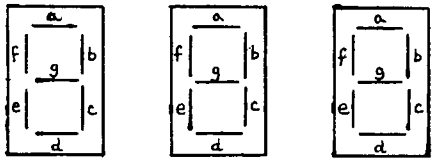


fig. 2

5 Two J-K bistables are connected as shown in the diagram below. The pulses from the clock have a pulse duration of 1.0 μs and a pulse separation of 2.0 μs. Draw the clock waveform and below it show the waveform appearing at Q_1 and Q_2. Show the pulse duration and the pulse separation in each case. (4 marks)



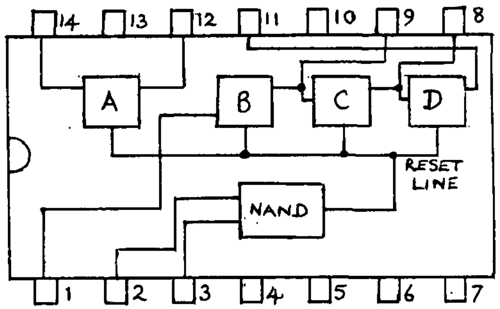
6 The three seven-segment light-emitting diode displays with common anodes, shown below, are to be operated in a time-multiplexed mode. The number to be displayed is decimal 357. If the ON time is to be 50 ms, complete the table opposite showing the logic level applied for each 50 ms interval to each cathode element and also to the anode of each display. *(6 marks)*



State two advantages of using a time-multiplexed display with seven-segment LEDs. *(2 marks)*

What property of the human eye makes a multiplexed display acceptable? State how the frequency of multiplexing affects the appearance of the display. *(2 marks)*

7 The internal connections and the pin function of a 7493 (a full 4-bit binary coded counter) is shown in the diagram below. The reset line will simultaneously return the outputs from the four bistables to logic 0 whenever it is at logic 0. The reset line is operated by the two-input NAND gate.



(a) Draw up a truth table for the NAND gate to show when the reset line is operating and when it is not operating. *(2 marks)*

(b) What three external connections (not counting the power supply) would you make to convert the 7493 into a divide by 10 counter? Explain your reasoning. *(5 marks)*

(c) Why is it not possible to convert the 7493 on its own to operate as a divide by 7 counter? *(2 marks)*

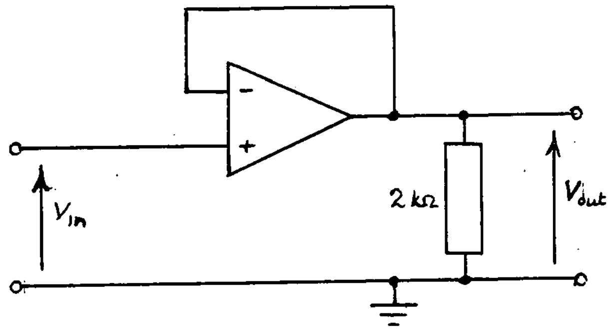
Question 6

Use this table for your answer

	DISPLAY 1								DISPLAY 2								DISPLAY 3							
	a	b	c	d	e	f	g	ANODE	a	b	c	d	e	f	g	ANODE	a	b	c	d	e	f	g	ANODE
first 50 ms																								
second 50 ms																								
third 50 ms																								
fourth 50 ms																								

Note: If this question were to be used in this form in an actual examination then the question paper would contain a tear-out sheet with the blank table printed on it as shown here.

8 An amplifier system is constructed as shown below.



Does this system amplify:

(a) voltage;

(b) current;

(c) power?

Explain your answers, and the use of such an amplifier system. *(8 marks)*

9 A given amplifier is said to::

(a) have a flat response from 20 Hz to 50 kHz,

(b) be directly coupled, and

(c) have a first-order frequency response.

Briefly explain the significance of these terms. *(6 marks)*

10 It is common for a microprocessor system to use an 8-bit data-bus and a 16-bit address-bus. Explain concisely the meaning and significance of this statement. *(6 marks)*

11 Compare and contrast the light-emitting-diode display with the liquid-crystal display. *(6 marks)*

12 Information coded in binary form generally requires 8 bits or more to specify a letter or number. Give four reasons why the use of binary coding is justified when designing a computer system to process and store information. *(4 marks)*

13 Briefly outline the principles of operation of a timing system based on

(a) a CR network,

(b) a quartz crystal. *(6 marks)*

14 Explain why the speech pattern of a person who becomes deaf is usually quite different from that of a person with normal hearing. *(5 marks)*

15 Certain control actions of the human body may be described as of the ON-OFF type. Give one example and explain your reasoning. *(3 marks)*

16 Explain, with the aid of a diagram, why the minimum command signal for the production of movement of the output position of a position-control servosystem might correspond to anything from virtually zero to one equivalent to twice the width of the dead band. *(6 marks)*

17 (a) Draw a diagram of the time waveforms of an amplitude-modulated wave in which the modulating waveform is a sine wave.

(b) What is meant by the modulation index (depth of modulation) of an amplitude-modulated signal.

(c) A carrier of frequency 850 kHz is amplitude modulated by a sinusoidal signal of frequency 8.0 kHz. What is the frequency range occupied by the sidebands? *(6 marks)*

18 Information is to be coded as a series of dots and dashes. An electromagnetic carrier-wave of wavelength 600 m is interrupted at intervals corresponding to the gaps between the dots and dashes. In order to produce an audible output signal of 1 kHz at the receiver, what frequency would you combine with the frequency received from the transmitter? *(3 marks)*

19 Distinguish between:

(a) random access memory and serial access memory,

(b) machine code and high level language, and

(c) volatile and non-volatile memory. *(6 marks)*

THE ASSOCIATED EXAMINING BOARD

for the General Certificate of Education

Advanced Level

ELECTRONIC SYSTEMS

Paper 2 **658/2**

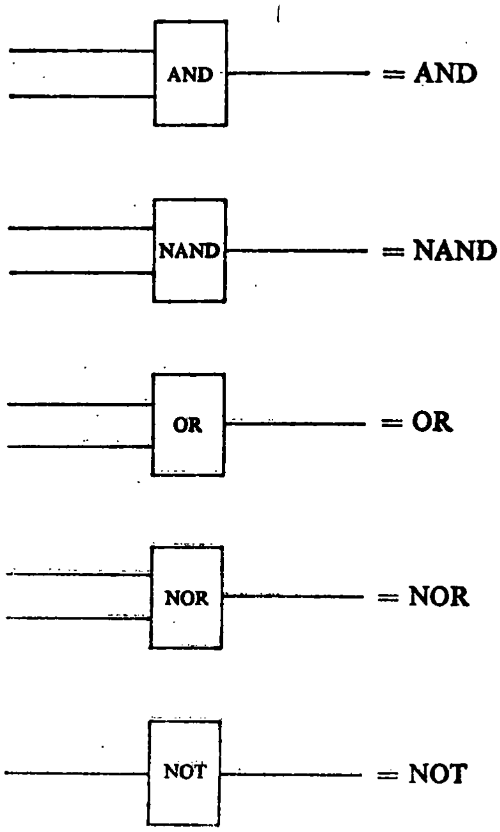
SPECIMEN PAPER

3 hours allowed

Answer all three questions in Section A.

Answer TWO questions from Section B.

In this paper the following logic symbols will be used throughout:



Assume that 0.7 V exists across a forward biased silicon diode and across the base-emitter junction of a transistor which is biased on.

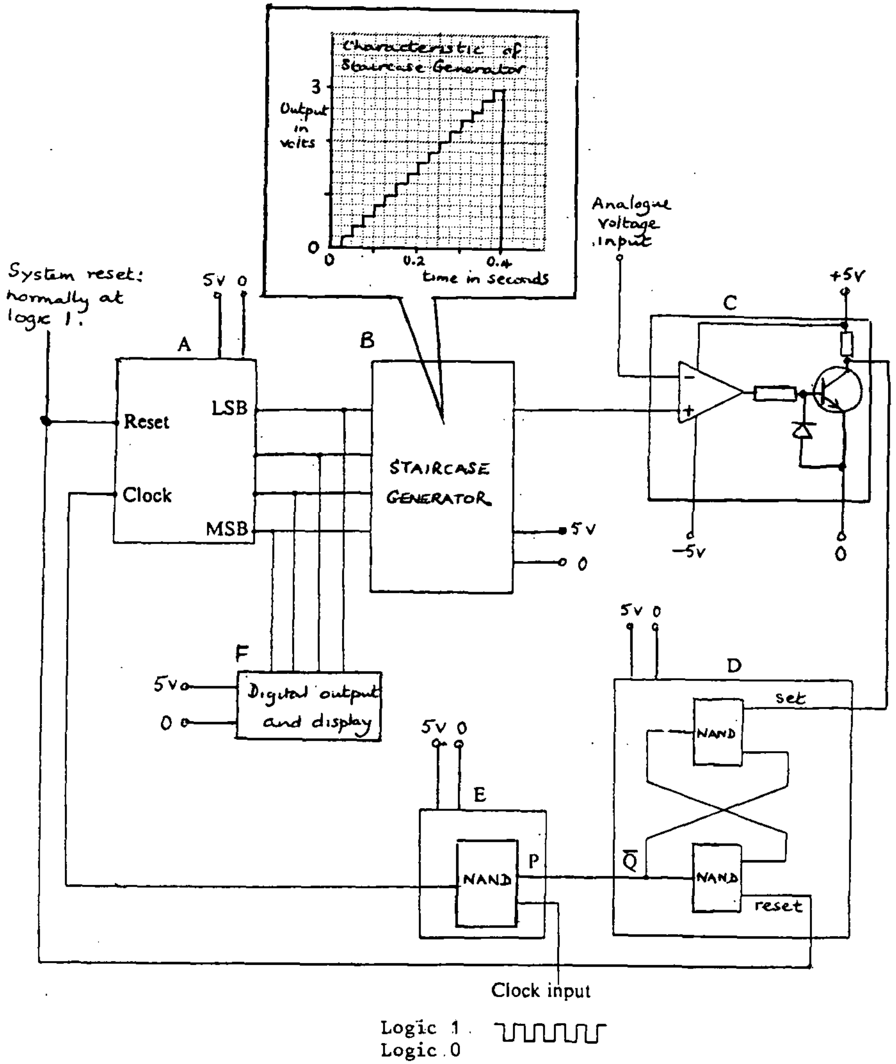
[*Turn over*

PAPER 2

SECTION A

Answer ALL questions in this section.

1 ANALYSIS OF SYSTEMS



The electronic system shown opposite is made up of six blocks lettered A to F. Its function is to produce a digital output which is proportional to the magnitude of the analogue voltage.

(a) Block A is a binary counter. If the pulse repetition rate of the clock is 40 pulses per second, what binary number will be shown on the display 100 ms after starting from zero? *(2 marks)*

(b) Block B produces a step in output voltage each time the binary count is incremented. The 16-level staircase has been designed to have a maximum value of 3 volts (see inset graph). If the binary input to block B is 1000, what is the output voltage from that block? *(2 marks)*

(c) Block C is a comparator. If the analogue input is 1 volt, draw the output waveform for a period of 0.4 second from the start of the counting cycle. Label time axes and voltage levels. *(3 marks)*

(d) Block E gates the clock pulses. Draw the output waveforms when the P input is

(i) at logic 1, and
(ii) at logic 0 *(2 marks)*

(e) Block D is a set-reset bistable using cross-coupled NAND gates. Its state table is as follows:-

Set	Reset	$\overline{Q}$
0	0	indeterminate
0	1	0
1	0	1
1	1	output state held

Explain the purpose of this block. *(2 marks)*

(f) This system operates sequentially in three states: reset, counting, and display. To return the binary counter to zero, it requires the reset to be taken from logic 1 to logic 0 for a short time and then back to logic 1. Explain the behaviour of the system in each of the three states. *(9 marks)*

2. An automatic gas boiler control system has several sub-systems.

The sub-systems are:

(i) A pilot-flame sensor that detects whether the pilot-flame is lit.

(ii) A gas valve for the pilot flame. This valve has a 'start' button which is pressed momentarily to open the valve to allow gas through. Once this button has been pressed the valve remains open. A 'stop' button is also provided: this button is pressed momentarily to turn off the gas.

(iii) A pilot-flame ignition system that operates provided that the gas valve is open and the pilot is not alight.

(iv) A main-burner gas valve with a mechanism that opens the valve when both the pilot is lit and the temperature of the water is below that set on the thermostat.

(a) Name a component in the system which is a 2-state sensor. *(1 mark)*

(b) Draw a block diagram of the complete gas-boiler control system. *(5 marks)*

(c) Identify one sub-system that uses feedback and state clearly which part of that sub-system is the feedback transducer and which part is the processing element. *(3 marks)*

(d) The main-burner control is performing a combinational logic function whereas the pilot gas-valve is performing a sequential logic function. By reference to these examples explain briefly what is the difference between *combinational logic* and *sequential logic*. *(4 marks)*

(e) Design an electronic logic system to implement the complete control system. In your answer state clearly the relationship between logic states and physical conditions for each input and output. Explain how your system works. *(7 marks)*

3 Some cars now use microprocessor systems for monitoring performance and communicating information to the driver by visual, audible, and verbal signals. This innovation has attracted numerous comments, such as:

- cars would not be so expensive if they did not have all these fancy gadgets
- it is far better if the system *tells* you that the petrol tank is nearly empty
- they use a woman's voice so that men will buy the car
- routine servicing can be much less frequent with such a comprehensive monitoring system fitted
- conditions in a car-engine compartment are far from ideal for using electronic equipment
- safety depends only on the driver, not the gadgets.

(a) Select two of these comments and discuss how far or in what ways these two comments can be regarded as valid or invalid. Support your answers with appropriate block diagrams of systems, quantative information and technical details. *(14 marks)*

(b) The first microprocessor systems used in cars only monitored performance, but it is also feasible to make these systems control the car. What would be the advantages and disadvantages of incorporating microprocessor control? How desirable would such a system be? *(6 marks)*

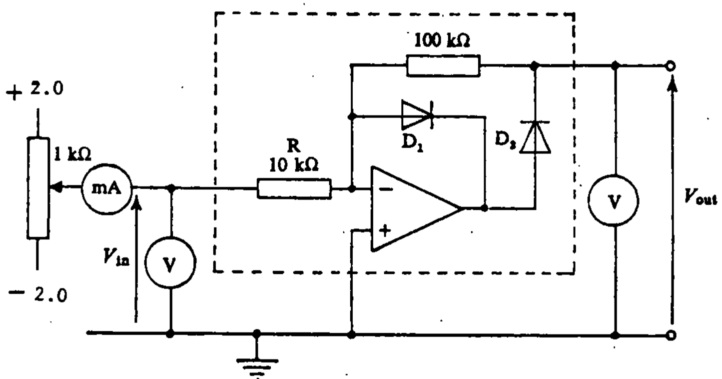
SECTION B

Answer TWO *questions.*

4 FEEDBACK SYSTEMS

(a) (i) Draw a labelled sketch-graph showing the variation of current with applied voltage for a typical general-purpose silicon diode. *(2 marks)*

(ii) Describe the variation of the effective resistance of the diode for forward-biased conditions. *(2 marks)*



$D_1 D_2$ are general-purpose silicon diodes.
The operational amplifier is powered by a +15-0-15 volt supply.

Fig 1

(b) The practical arrangement shown in Fig 1 is used to investigate the properties of the circuit defined by the box outline.

(i) Draw labelled sketch graphs and explain the principal features of theses graphs for:
an input characteristic showing the variation of input current with input voltage; and *(2 marks)*

a transfer characteristic showing the variation of output voltage with input voltage. *(5 marks)*

(ii) State what factors determine the input and output resistances of the circuit for d.c. conditions. *(3 marks)*

(iii) Briefly describe the behaviour of the circuit and state what useful property it possesses. *(2 marks)*

(iv) How would the behaviour of the circuit differ if the resistor R (10 kΩ in the diagram) were replaced by a resistor of value 1 kΩ? *(2 marks)*

(v) What would be the output waveform of the circuit if the signal shown in Fig 2 were connected to the input of the circuit shown in Fig 1 with R = 10 kΩ?

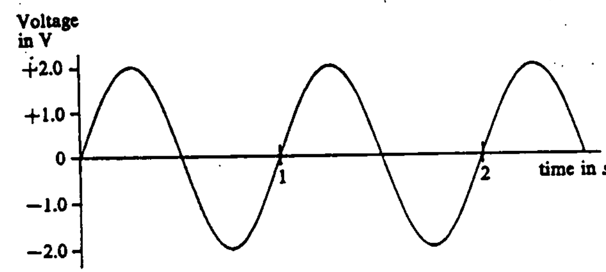


Fig 2 *(2 marks)*

5. INFORMATION SYSTEMS

(a) Distinguish between the terms *digital* and *analogue* as used in information systems. *(2 marks)*

(b) Information may be represented, stored, processed and communicated in digital, analogue or hybrid form.

Allocate the following systems to the appropriate classification. Outline your reasoning in each case.

(i) A proportional position-control servosystem. *(2 marks)*

(ii) A telecommunications system conveying speech between two persons by a pulse code modulation technique. *(2 marks)*

(iii) A floppy disc store. *(2 marks)*

(c) The human being can recognise complex patterns.

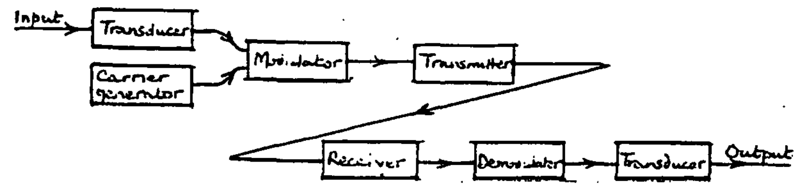
(i) Briefly outline the processes by which visual information becomes the data transmitted to the human brain and recognised as a pattern. *(6 marks)*

(ii) Briefly discuss why pattern recognition is a difficult task to be performed by a technological system. *(2 marks)*

(d) Information may be stored in either digital or analogue form. Discuss the relative merits of storing information in either form on magnetic tape. *(4 marks)*

6. COMMUNICATION SYSTEMS

The diagram shows a communication system in generalised form.



(a) Briefly describe the function of each of the labelled elements in a radio communication system. *(10 marks)*

(b) Explain briefly how information is coded, transmitted, received and decoded in a simple linear PCM (pulse-code modulated) system. *(7 marks)*

(c) Optical fibres may be used for a PCM communication system. State three benefits of transmitting information in this way. *(3 marks)*

7. CONTROL SYSTEMS

(a) What is a transducer? For (i) position, and (ii) temperature, identify a suitable transducer that provides an electrical output and outline its principle of operation. *(7 marks)*

(b) Draw a generalised block diagram showing the basic elements of a closed-loop feedback system. *(4 marks)*

(c) How is the performance of a control system improved by the use of feedback? Describe the behaviour of a simple proportional position-control servosystem employing feedback. *(3 marks)*

(d) Explain why a simple proportional-positional control servosystem may oscillate when disturbed and discuss what factors would control the *amplitude* and the *period* of these oscillations. What factors would control the duration of the oscillations? *(6 marks)*

NOTES

FOR THE GUIDANCE

OF

TEACHERS

Conventions for Symbols, Diagrams and Units

is section gives details of the various
onventions that will be employed in question
apers. It is hoped that teachers will employ
e same conventions and encourage their use by
ndidates. However, candidates will not be
enalised if they do not use these specific
nventions, providing the symbols used are
adily identifiable and consistent.

1 Units

Units will conform with the British Standard Institute publication 'The Use of SI Units', PD5686: 1972, to which the Board's policy document, 'The Use of Units', 5/DM also refers.

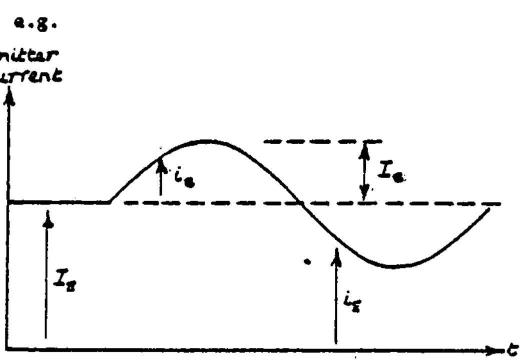
2 Text, Symbols, Subscripts, etc.

Where letters are used in equations to represent quantities, the letters will be printed as italics. Where letters are used as labels, they will be printed in roman type. Thus *R* is a value of resistance in ohms (or any other unit) whereas R is a label for a resistor. (Symbols will be in accordance with those indicated in the ASE publication "SI Units, Signs, Symbols and Abbreviations".)

antity Symbols:

antity symbols published in the syllabus and
examination questions will follow the practice
id down in BS 3363. Candidates will not be
nalised for a different usage provided that it
clear and unambiguous. The advantage of
3363 is that it clearly distinguishes between
e varying and constant components of a signal.
quantity symbol generally consists of both a
in symbol and a subscript, the main symbol
noting the quantity and the subscript the
rt of the circuit to which it refers.
fferent cases are used to distinguish different
mponents of the signal:

antity symbol	Subscript	Meaning
lower case....	lower case...	instantaneous value of the varying component
lower case....	capitals....	instantaneous value of the total signal
capitals......	lower case...	RMS value of varying component
capitals......	capitals.....	DC value (no signal)



With a 3 terminal device, such as a transistor, 3 subscripts are used:

1st: terminal at which quantity is measured

2nd: reference terminal or symbol to indicate configuration of circuit (may be omitted if meaning is clear)

3rd: indicates state of the 3rd terminal

X - reverse biased

O - open circuit

S - shorted to the reference terminal (2nd subscript) (omitted if the third terminal is not necessarily in one of these conditions)

The supply voltage is denoted by repeating the subscripts:

Examples: i_b: instantaneous value of the varying component of base current

v_{CE}: instantaneous value of collector-emitter voltage

V_{CC}: supply voltage (the supply connected through some network to the collector terminal)

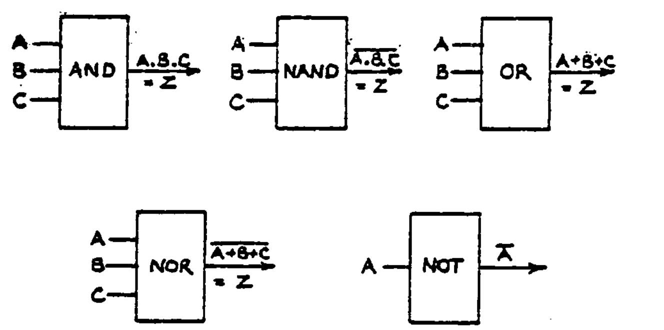
1.3 CIRCUIT SYMBOLS AND CIRCUIT DIAGRAMS

Diagrams published in the syllabus and in examination questions will be to BS 3939. However, it is recognised that some of the symbols in this standard are not those in common use. Candidates must *recognise* BS 3939 symbols but will not be penalised for using something different in their answer if their usage is clear and unambiguous.

Shortened versions of BS 3939 have been prepared by and can be obtained from the British Standards Institute. PP400 is reprinted here (with the permission of BSI). PD7303 is an abstract which gives all the detail normally required by a school or College, and includes a wall poster showing the commoner symbols.

1.4 LOGIC SYMBOLS

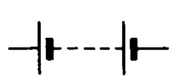
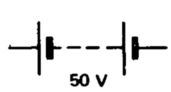
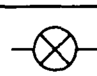
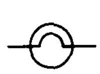
To preserve simplicity and uniformity, the system of symbols used for the purpose of the examination is outlined below.

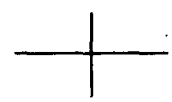
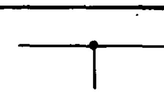
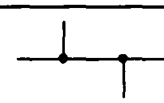
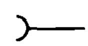
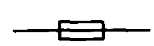
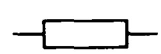
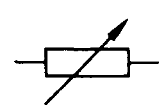
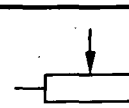
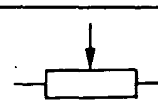


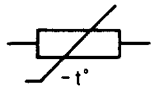
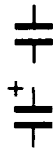
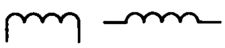
Other functional blocks will also be indicated by labelled 'boxes'. Whilst this is not BS 3939, the Board specifies this system as a simplified form of BS 3939 which will not lead to possible confusion. Students should readily accept the normal BS 3939 symbols with no difficulty later if they have become familiar with this system. The symbols shown here do not include the small circle to denote NOT. Candidates would not be penalised for using this symbol for NOT, but teachers should recognise that candidates might write, say, NAND in a square box and add the circle, thereby in fact indicating AND.

EDUCATION
INFORMATION

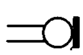
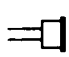
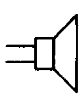
PP 400: SELECTED ELECTRICAL AND ELECTRONIC GRAPHICAL SYMBOLS from BS 3939

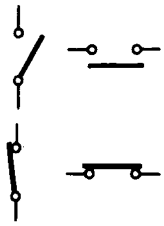
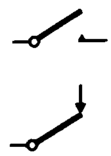
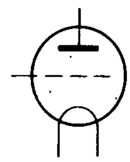
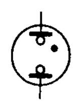
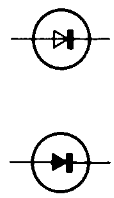
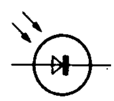
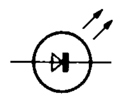
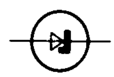
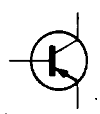
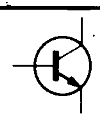
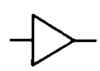
Description	Symbol
Direct current or steady voltage	—
Alternating	∼
Positive polarity	+
Negative polarity	−
Rectifier	
Variability	
Primary or secondary cell	
Battery of primary or secondary cells	
Alternative symbol	
Example: 50 V battery	
Earth	
Aerial (antenna)	
Signal lamp	
Filament lamp	

Description	Symbol
Electric bell	
Crossing of conductor symbols on a diagram (no electrical connection)	
Junction of conductors	
Double junction of conductors	
Plug (male)	
Socket (female)	
Fuse	
Alternative symbol	
Fixed resistor	
Alternative symbol	
Variable resistor	
Resistor with moving contact	
Voltage divider with moving contact	

Description	Symbol
Heater	
Thermistor	
Capacitor: general symbol Polarized capacitor	
Polarized electrolytic capacitor	
Capacitor with preset adjustment	
Winding	
Inductor + core Transformer	

Description	Symbol	Description	Symbol
Ammeter	(A)	Ohmmeter	(Ω)
Voltmeter	(V)	Wattmeter	(W)
Wavemeter	(λ)	Galvanometer	

Oscilloscope	
Motor Generator	(M) (G)
Microphone	
Earphone (receiver)	
Loudspeaker	
Clock (and slave clock)	

Description	Symbol
Make contact (normally open) Break contact (normally closed)	
Relay make contact-unit break contact-unit	
Thermionic valve: triode, directly heated	
Neon lamp	
p n diode Alternative symbol	
Light-sensitive *p n* diode	
Light-emitting diode LED	
Zener diode	
p n p transistor	
n p n transistor	
Amplifier	

Teachers may duplicate this sheet for the use of their class.

ENQUIRIES:
Technical Education Officer

PP400/8010/5k/DP

2. Practical Work

This syllabus is based on the assumption that the course followed by candidates will have a significant practical component. Part of this practical work is assessed for the examination, but it is not envisaged that the assessed work will be the only practical work undertaken by the candidate.

The assessment will be based on a project and on the candidate's laboratory notebook (log book) containing a record of practical assignments undertaken during the year immediately preceding the examination.

2.1 Time allocation for assessed practical work

It is expected that the project submitted as part of the courswork requirement will be undertaken by students during the latter part of the course, and that the project will normally require four weeks of classroom time for its completion. This is equivalent to 20 hours of productive laboratory work, time for planning, preparation and report writing being additional to the 20 hours. Whilst candidates should not be permitted to spend much more than the specified time on the project, the Board does not expect the 20 hour period to be rigidly enforced. A candidate who, for an additional hour or two, would complete a worthwhile piece of work should if possible be allowed to do so.

For the laboratory assignments, the assessment is based on a minimum of six experiments each of at least four hours duration (or equivalent laboratory work), undertaken by the candidate in the year immediately prior to the examination.

2.2 Teaching Approach for Practical Work

The practical work for Electronic Systems is not intended as a set of routine procedures or highly structured exercises designed to produce a predetermined result for which concurrence with the teacher's expectations is the sole criterion of excellence. It is intended to allow the student scope, once basic procedures have been mastered, to think about the underlying principles, by such means as exercising choice in selection and organisation of components, apparatus and/or methods, in the recording and processing of results, and in the format and content of reports. This principle is extended further in the project, where the student is expected to select his own project, specify what is to be achieved, plan the activity, and evaluate the outcome, but doing all of these things under the guidance of the teacher. It is this range of skills and activities which characterises the Advanced Level nature of this practical component.

Teachers do need to strike a correct balance between allowing students to get on with their own work (whatever mistakes they may be making) because it is to be assessed as part of the examination, and giving appropriate help and guidance because the practical work is an essential and integral part of the teaching programme. The key to this problem is in allowing the student to make the decisions. The Board expects teachers to guide their students, but the approach should not be "do this" but, say, "have you thought about ..." or, where a direct question is asked, "you could use this or that ...". There are occasions where nothing other than direct help or intervention will do. In these cases the student is expected to acknowledge this help explicitly, and the teacher is expected to make a note of such help on the student's assessment form. The Board would much prefer that a candidate receives this kind of help, with relevant notification given, than to find that a candidate has been unable to carry out the task for want of necessary guidance and therefore loses not only the marks for skills he could not demonstrate but also marks for, say, report writing and basic skills which he may well deserve.

The Board's Moderators are practising teachers, well experienced in the approach indicated here and the problems it can generate. Where significant difficulties do arise, teachers are advised to provide as much relevant information to the Moderator as they can (normally with the assessment form) so that the Moderators can make a fair - and, where necessary, sympathetic - assessment.

2.3 Typical projects

There is no specified list of coursework or project exercises and it is considered one of the strengths of this syllabus that a wide variety of topics can be employed. The suitability of a topic is determined by whether it provides the student with adequate opportunity to obtain marks for each of the criteria specified in the marking scheme (Form ES3/4). It should be noted that it is the <u>opportunity</u> that should be available, rather than an expectation of gaining marks for all criteria. Good candidates will score most of the available marks but weaker candidates will not make adequate use of the opportunities their topics provide to earn the marks available in the various categories.

The assessment scheme is designed to assess skills. A fairly simple project, well done, is frequently a better route to good marks (even for a very able student) than a complex system. Complex systems are time consuming, often incomplete, difficult to evaluate, and troublesome to get working if, as nearly always, there are faults in the system which must be identified.

Suitable projects may be regarded as falling into four general categories, which are:

A Measurement exercises
B An investigation
C Circuit design
D System synthesis

The following lists of topics are included as <u>examples</u> of the kind of project which is considered suitable.

A Measurement Exercises

1. Circuit limitations as a result of device characteristics, e.g. frequency response of operational amplifier circuits.

2. Comparison of relay and transistor switching rates.

3. Measurement of the speed of sound by direct timing.

4. Comparison of flicker fusion rate for direct and sideways observation.

5. Effect of L/C ratio and resistance on the selectivity of an L.C.R. resonant circuit.

6. Measurement of the frequency response of a flame loudspeaker.

7. Measurement of the property variation for a temperature dependent device and its conversion to a variable on/off response.

8. Measurement of the frequency response of an inductive capacitor.

9. Harmonic analysis of a waveform using beats.

0. Measurement of magnetic fields with an "integrated" search coil output.

1. Comparison of the efficiency of Class A and B power amplifiers.

2. Measurement of the efficiency of a loudspeaker.

3. An investigation of the effectiveness of smoothing circuits.

B An Investigation

1. Possibilities of modulated light transmission.

2. Possibilities of modulated light reception.

3. Modified response of a human controller as a result of learning and tiredness in a control situation, e.g. temperature regulation of a heatsink.

4. Measurement of the speed of a linear motor by counting pulses reflected from a rotating cam.

5. Investigation of binaural hearing.

6. Effect of colour and intensity of stimuli on reaction response time.

7. Using pulse width modulation to transmit audio signals.

8. Development of an analogue computer to simulate a bouncing ball moving in a variable viscosity medium.

9. Production of a tangential tracking system for a record player pick-up.

0. Effect of alcohol and noise on reaction time.

1. Effect of intermittent interruption of visual feedback on tracing ability. Is usual feedback control a two co-ordinate system?

2. Effect of delayed auditory feedback on speech capability. Effects of actual time delay and intensity of feedback signal. Time for controlled suppression of feedback signal.

C Circuit Design

1. Design of a Schmitt trigger circuit and investigation of its real as compared to design response.

2. Design of a simple astable multivibrator with stepped variable mark to space ratio.

3. Design of a simple common emitter transistor power amplifier to drive a particular load.

4. Circuit to display frequency dependent characteristics on an oscilloscope.

5. Circuit to switch after preset time intervals.

6. B.C.D. adder using 7400 gates only.

7. Electronic combination lock design with lock-out and alarm.

8. A school bell system operating from a digital clock.

9. Wave height measurement using resistance probes.

10. Construction of an electrical analogue of the rainwater cycle from sea to mountain top and back.

11. Construction of an electrical analogue of a warehousing system.

12. An attempt to synthesize a speech waveform.

13. Motor speed control by use of a multivibrator.

D System Synthesis

1. Digital to analogue conversion and the use of the resulting voltage to control frequency.

2. Production of a light sensitive device to scan a black and white picture.

3. System to switch a dynamo over to battery power at low cycle speeds.

4. Colour indicator for mains wire to enable a blind person to wire a plug.

5. Automatic traffic light system dependent on counting cars and time intervals.

6. A fluid flow meter counting water wheel revolutions.

7. Ghost detection by humidity and temperature variation detection.

8. Controlling a conveyor belt speed to feed objects at a constant rate if distribution random.

9. Alarm for sleepy train driver.

10. Electronic organ.

11. Steering a model submarine towards a sound source.

12. A pulse rate measuring device.

13. Digital compass.

14. Digital water depth measurer.

15. Manufacture of an electrocardiograph.

2.4 Typical coursework assignments

As an indication of typical coursework, the assignments described in the Essex University teaching texts are listed here.

Systems and Systems Components:

The diode and the transistor as a switch
Power supplies experiment

COMMUNICATION SYSTEMS

Frequency response of audio systems
Amplitude demodulation
Power in electronic circuits

PROCESSING SYSTEMS

Parallel computer experiment
Serial computer experiment
Logic gates experiment
Sequential circuits

FEEDBACK SYSTEMS

The operational amplifier in resistive feedback circuits
Servo systems experiment
Analogue computer experiment

2.5 Administrative procedures

This section gives an outline of the various stages in the assessment programme. For further details refer to the notes included on forms ES1 (the Project Brief) and ES3/4 (the assessment form); copies of these forms are included as appendices to these notes.

(a) By 15th October in the Autumn prior to the examination, notify the Board by letter of the provisional number of candidates to be entered and the number of Project Brief forms (ES1) required. The Board will forward these forms, the form ES2 (candidate summary) and the name and address of the Moderator for the centre.

(b) Not later than 31st March, where prior approval is required, submit completed Project Brief forms to the Moderator. Prior approval is needed for proposals involving a significant amount of computer programming, and for projects which do not involve electronic hardware. Where proposals are not in these special categories, approval of a proposal is the responsibility of the teacher and Project Briefs should not be submitted to the Moderator until the Project is complete.

(c) During March or the first part of April - The Board will send out sufficient assessment forms (ES3/4) and covers (ES6) for the number of candidates entered.

(d) Before 15th May - the teacher should assess the coursework (log-book) and projects using the assessment scheme provided by the Board.

(e) Not later than 15th May - the Moderator should receive the project reports for all candidates, together with Project Briefs and the completed assessment forms for each candidate. Log-books should not be submitted, but they must be retained at the centre until the end of June since the Moderator might ask for the log-books to be submitted for moderation in addition to the projects.

The following points should be noted:

(i) Form ES2 is a triplicate form. The top copy should be enclosed with the Projects when submitted. The second copy should accompany any Project Briefs which are submitted (note (b) above). The third copy should be retained at the centre.

(ii) Project reports will NOT be returned. Candidates requiring a copy of their work must make such a copy before the report is submitted. The original report must be submitted to the Board, not a photocopy.

(iii) The Project Report should include a completed Project Brief and a photograph of the hardware associated with each project. Such photographs should be of the circuitry,etc, rather than the front panel or a finished encased artefact.

(iv) It is a Board requirement that all components of an examination must be attempted if a result is to be issued. The coursework on which the assessment is made must include both hardware which has been photographed, and a project report, in order to be acceptable. If either is not submitted for assessment the candidate will be deemed not to have attempted the coursework component. A log book of experimental assignments is not an acceptable substitute for a project or a project report.

(v) Candidates often have little or no experience of report writing. It is therefore desirable that teachers include in their courses provision for training or practice in report writing as preparation for the task of preparing the final reports for assessment.

(vi) Moderation procedures depend entirely on the written reports. Assessors are therefore requested to give as much information as they can to support the assessments they have made. Such information could be included on the cover of the project, or on a sheet attached to the project, or in a separate letter to the Moderator, as appropriate. This will help Moderators to interpret the Centre's assessment fairly and reduce the deficiencies arising from some candidates' inability to do justice to themselves in their reports.

(vii) Teachers will serve the best interests of their candidates by attempting to get their marking standard in close agreement with the standard applied by the Moderator. Over generosity or severity will result in the Moderator reassessing the reports, and this assessment will inevitably be made without detailed knowledge of the work of the candidate through the course. In this context it should be noted that one of the functions of the marking scheme is

discriminate. Whilst almost all
ıdidates will score marks on the
rst question in some of the
sessment groups, few will score full
rks in any assessment group and very
v will score full marks in most
oups.

Syllabus topics

purpose of these notes is to explain more
lly those parts of the syllabus that may be
familiar to teachers. These notes are not
ended to be a substitute for text books
the treatment is necessarily brief.

a full discussion of these points teachers
referred to an appropriate book: a book
t is given at the end of these notes.

l General Systems (Syllabus Section 1)

s syllabus is intended to be about
tems and particularly electronic
tems. Candidates are expected to be
e to apply systems principles to
cribe the behaviour of a system
sented in an examination. Teachers
, therefore, advised to discuss a
ber of systems (including non-
ctronic systems) in class and to show
the features of syllabus section 1
ear. The list of possible examples
almost limitless, but the following
gestions will illustrate the range:
estic equipment such as a washing
hine or vacuum cleaner, computer data
rage, transport systems, commercial
d processing, thermostatic and
eostatic (biological) systems,
ustrial control and automation.

considering transfer characteristics,
-electronic amplifiers (eg car brake
vo system), thermostatic, ecological
homeostatic systems could usefully be
cussed with students in addition to
ctronic systems.

will also help students to relate
ctronic systems to systems in general if
characteristics of mechanical systems
compared with those of programmed
ctronic systems. For example, a gear
has a built-in program in so far as the
put speeds are related to the input
eds by the programmed relationship of
r ratios, this relationship being a form
memory equivalent to ROM

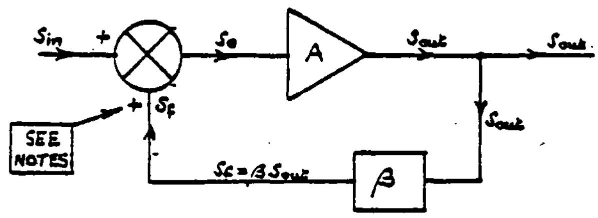
universality of the processing of
ormation, of its communication, and
trol (including feedback) as elements
a system should also be understood by
dents. These elements should be
arded as major cohesive themes of the
labus to which the teacher should
eatedly refer as the students'
erstanding develops. Although the
labus has separated these three elements
ir relevance is as elements in systems
not separate entities in their own
ıt.

Directly coupled amplifiers (Syllabus section 2.3)

didates are expected to appreciate the
sons why capacitors are often used to
ple between stages in an amplifier;
y are also expected to know
alitatively) the effect capacitor
pling has on the overall frequency
ponse. From this they will be
ected to be able to explain why
directly coupled amplifiers have to be
used if the signal contains a d.c.
component.

3.3. Feedback (Syllabus section 2.3)

A feedback amplifier system takes the general form shown in the diagram below; s is used to denote "signal": this signal can be voltage or current.



Notes: (i) A is the *open-loop gain* gain of the amplifier

(ii) β is the *feedback factor* ($s_f/s_{out} = \beta$)

(iii) A and β can each be positive or negative (in real systems A and β may be complex but that is not required for this syllabus)

(iv) s_{out} may be a voltage or a current: s_f may be a voltage or a current, but need not necessarily be the same as s_{out} (i.e. β may in real systems have dimensions of impedance or admittance). There are, therefore, four combinations:

s_{out} voltage ; s_f voltage

s_{out} voltage ; s_f current

s_{out} current ; s_f voltage

s_{out} current ; s_f current

For the purposes of this syllabus candidates need only consider general feedback systems where all quantities are signals (s) or practical systems where all quantities are voltages. The latter type of feedback system (s_{out} and s_f both being voltage) is known as *series-voltage feedback*.

When consulting books about practical feedback amplifiers teachers are advised to be careful about selecting only series-voltage feedback circuits.

(v) In the diagram given above it should be noted that the feedback signal is added to the input signal to produce the error signal. This is purely sign convention: it has nothing to do with whether the feedback is positive or negative. Some books (particularly those concerned with feedback in control systems) use the convention of subtraction here and write $s_e = s_{in} - s_f$.

Analysing the circuit:

$$s_e = s_{in} + s_f = s_{in} + \beta\, s_{out}$$

$$s_{out} = A\, s_e$$

so that $$\frac{s_{out}}{s_{in}} = A' = \frac{A}{1-A\beta}$$

A' is known as the *closed-loop gain*

$A\beta$ is known as the *loop gain*

(Note: the other sign convention gives: $A' = A/(1 + A\beta)$)

Negative feedback: the feedback is said to be negative

if $A' < A$

i.e. if $|1 - A\beta| > 1$

Positive feedback: the feedback is said to be positive

if $A' > A$

i.e. if $|1 - A\beta| < 1$

Notes: (i) positive feedback does not necessarily mean that the amplifier is unstable: it means that the gain with feedback is greater than the gain without.

(ii) it is best to write the conditions for negative feedback and positive feedback in terms of the magnitude of the denominator as this avoids any confusion with the signs.

Convention

	Preferred convention for this syllabus	Convention often used in Control System analysis
	$s_e = s_{in} + s_f$	$s_e = s_{in} - s_f$
A'	$A/(1 - A\beta)$	$A(1 + A\beta)$
Negative feedback	$|1 - A\beta| > 1$ $A\beta$ negative	$|1 + A\beta| > 1$ $A\beta$ positive
	possible confusion between conventions	
Positive feedback	$|1 - A\beta| < 1$ $A\beta$ positive	$|1 + A\beta| < 1$ $A\beta$ negative
	possible confusion between conventions	

For real systems it is essential to write the condition in terms of the magnitude of the denominator since $A\beta$ is complex.

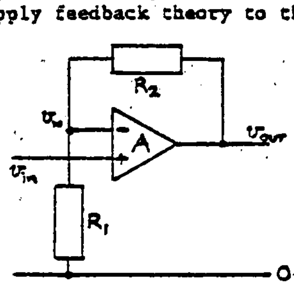
Stability

Candidates are expected to be able to answer examination questions about changes in A' as A is varied by substituting the appropriate values in $A/(1 - A\beta)$ and comparing results.

Large Value Gain

Candidates are expected to be able to manipulate $A' = A/(1 - A\beta)$ into $A' = 1/(1/A - \beta)$ and to know that $A' \to -1/\beta$ as A gets large.

A useful application of this is the non-inverting operational amplifier circuit (it is difficult to apply feedback theory to the inverting configuation).



$v_{OUT} = A(v_{IN} - v_M)$

the general expression is

$s_{out} = A\ s_e = A\ (s_{in} + s_f)$

so $s_f = -v_M$

$\beta = s_f/s_{out} = -v_M/v_{OUT}$

but $v_M = v_{OUT}\ [R_1/(R_1 + R_2)]$ so $\beta = -\dfrac{R_1}{R_1 + R_2}$

This is an application where A is very large so $A = 1/\beta$

here $-\dfrac{1}{\beta} = +\dfrac{(R_1 + R_2)}{R_1} = 1 + \dfrac{R_2}{R_1}$

which is the standard expression.

3.4 <u>Decibel Scale</u> (Syllabus section 2.3)

The decibel scale is something that is often used incorrectly. Strictly the decibel is a measure of a power ratio:

n (in dB) is 10 lg (P_1/P_2)

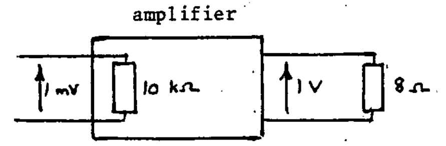
(using lg to denote $\log_{10}$)

Confusion often arises when voltage ratios are epxressed in dB. It is common to see the expression:

n (in dB) = 20 lg (V_1/V_2)

This may, or may not, be correct.

For an example of a cause of confusion, consider a numerical example of an amplifier:



The amplifer develops an output voltage of 1 V into an 8 Ω load when an input signal of 1 mV is applied; the amplifier has an input resistance of 10 kΩ.

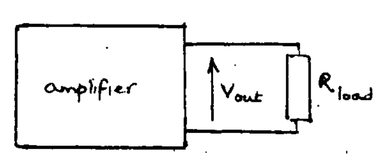
Applying the relation n = 20 lg (V_{out}/V_{in}) gives a gain of 60 dB; applying n = 10 lg (P_{out}/P_{in}) gives a gain of 91 dB.

Confusion arises because people talk about gains in dB without being careful to state whether it is the power gain (the strictly correct use) that is being considered or the voltage gain.

For the amplifier the strictly correct expression is

n (in dB) = 20 lg (V_{out}/V_{in}) + 10 lg (R_{in}/R_{load})

In this syllabus the decibel is restricted to use in considering a frequency response: in this application the expression for voltage response and power response is the same.



V_{out} is a function of frequency

The frequency response (for a low-pass shape) in terms of power is $P_{out}(\omega)/P_{out}(\omega = 0)$ as a function of ω (where $\omega = 2\pi f$)

Expressing this in dB gives:

n (dB) = 20 lg $(V_{out}(\omega)/V_{out}(\omega = 0)$

+ 10 lg (R_{load}/R_{load}) (= 10 lg 1 =

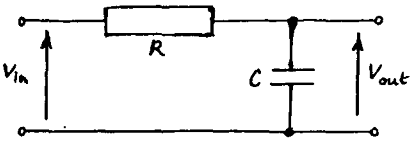
This is the same as expressing the frequency response as a voltage transfer function. Note that n at $\omega = 0$ must be 0.

Note too that the quantity V_{out} is the magnitude of the a.c. voltage: the phase term is considered separately (not in dB).

3.5 Frequency response and bandwidth (Syllabus section 2.3

In this section it is important to remember the effect of phase. Although this syllabus does not include the use of j-notation it is used here in order to explain where confusion may arise. Teachers should not attempt to teach students any of the derivations in this section, or j-notation. However, it is included in the hope that teachers will avoid introducing ideas which have to be "unlearned" later.

A low pass first order frequency response is that obtained from a simple RC circuit

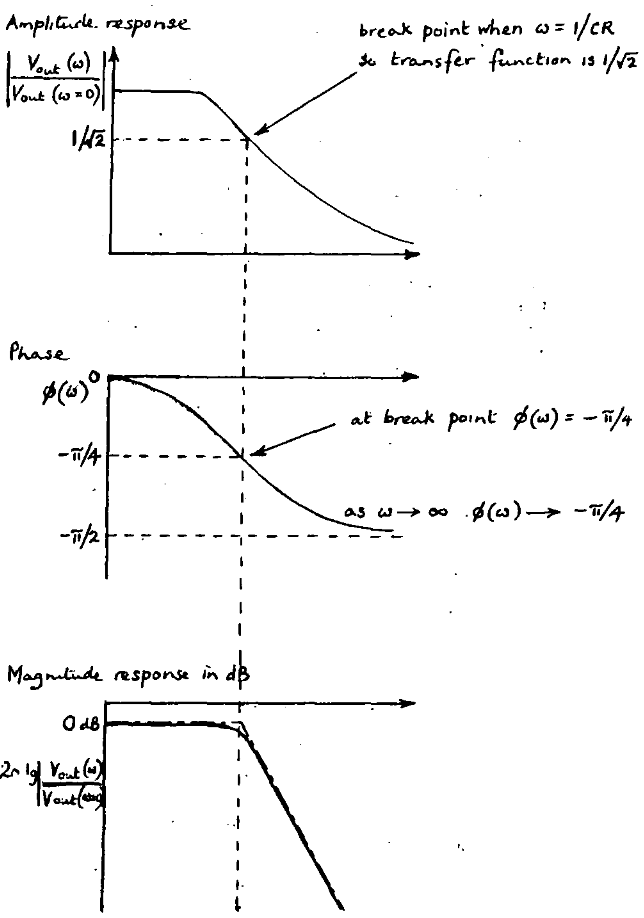


$$\frac{V_{out}(\omega)}{V_{in}} = \frac{1/j\omega C}{R + 1/j\omega C} = \frac{1}{1 + j\omega CR}$$

at $\omega = 0$ $V_{out} = V_{in}$ so $\frac{V_{out}(\omega)}{V_{in}} = \frac{1}{1 + j\omega CR}$

The amplitude response is $\left|\frac{V_{out}(\omega)}{V_{out}(\omega=0)}\right| = \sqrt{\frac{1}{1 + \omega^2 C^2 R^2}}$

The phase response is $\phi(\omega) = \tan^{-1} -(\omega CR)$
(Note that phase is a relative quantity so does not need to be expressed as a ratio).



There are a number of interesting points about the magnitude response expressed in dB:

(i) at the origin its value is 0 dB

(ii) at the break point its value is is approximately - 3 dB

(iii) the asymptotic slope as $\omega \to \infty$ is - 20 dB/decade. (- 6 dB/octave)

This is shown as follows:

$$n = 20 \lg \sqrt{\frac{1}{1 + \omega^2 C^2 R^2}} \cong 20 \lg \sqrt{\omega^2 C^2 R^2}$$

(as $\omega CR > 1$ beyond the breakpoint so that $\omega^2 C^2 R^2 \gg 1$)

$n \; (\omega_1) = -20 \lg \; \omega CR$

$n \; (\omega = 10\omega_1) = -20 \lg \; 10\omega CR =$
$- 20 \lg \; \omega CR - 20$

so that over 1 decade of frequency the amplitude has been reduced by 20 dB.

(iv) the frequency response can be approximated to the chain-dotted line shown in the sketch.

For $\omega \leqslant \omega_o$ the response is taken as 0 dB

For $\omega \geqslant \omega_o$ the response is $-20 \lg \omega CR$

but CR is $1/\omega_o$ so the response is $-20 \lg \; \omega/\omega_o$

The situation is complicated when feedback is applied. Consider an amplifer with a first-order response: the frequency response is now

$$\frac{V_{out}(\omega)}{V_{out}(\omega=0)} = \frac{A_o}{1 + j\omega CR} = \frac{A_o}{1 + j\omega/\omega_o}$$

Where A_o is the voltage gain at $\omega = 0$

This is the expression for A in the feedback expression. If feedback is now applied (using conventions so that $A' = A/(1 - A\beta)$) and assuming β is constant with frequency

$$A' = \frac{A_o/(1 + j\omega/\omega_o)}{1 - A_o\beta/(1 + j\omega/\omega_o)}$$

Note that the feedback expression must be applied before taking the modulus.

Hence $A' = \frac{A_o}{1 - A_o\beta + j\omega/\omega_o}$

$$= \frac{A_o/ (1 - A_o\beta)}{1 + (j\omega/\omega_o/(1 - A_o\beta)}$$

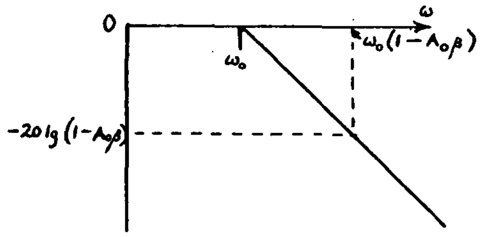
This can be written as:

$$A' = \frac{A_o}{1 - A_o\beta} \times \frac{1}{1 + j\omega/(1 - A_o\beta)\,\omega_o}$$

This is a first order response with break point of $(1 - A_o\beta)\omega_o$; the asymptotic slope is the same as is obtained without feedback.

Hence if we plot the frequency response

in dB using the linear approximation, the following curve is obtained:-



Notice that the use of negative feedback has reduced the gain but increased the bandwidth.

Candidates may be required to make use of this graph to calculate the effects of feedback but they will not be expected to make use of j-notation to derive it. Candidates should appreciate that the graph is an approximation and that the maximum error, which is 3 dB, occurs at the break point.

3.6 Relationship between bandwidth and rise time (Syllabus section 2.3)

The response to a step input that is obtained from low pass RC circuit is

$V = V_o (1 - \exp(-t/RC))$

Hence the time for the voltage to reach 90% of the step value V_o is given by solving

$$0.9V_o = V_o(1 - \exp(-t/RC))$$

which gives

$$t = RC \ln 10 \approx 2.3\,RC$$

but as shown in the previous section

$$RC = 1/\omega_o$$

so that the rise time t_r is given by the expression

$$t_r = 2.3/\omega_o = 2.3/2\pi f_o \approx 0.37/f_o$$

Usually t_r is taken as $0.35/f_o$

Although explained here in terms of a RC circuit this can be extended to any first-order low-pass response.

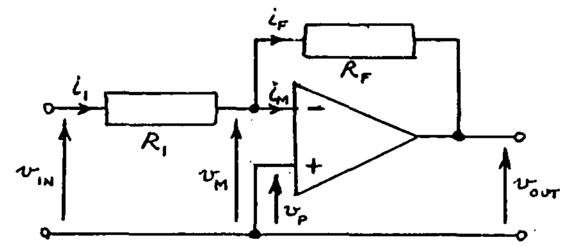
Candidates are expected to know that the response of a first-order low-pass circuit takes the exponential form and to be able to use the relationship between bandwidth and rise time.

3.7 Operational Amplifiers (Syllabus section 2.5)

Teachers are referred to appropriate textbooks for detailed derivation of the appropriate equations.

However, teachers may like to know that considerable algebraic manipulation can be avoided by making use of a physical principle of the ideal operational amplifier; since the gain is infinite the operational amplifier will saturate unless both inputs are equal. Negative feedback acts to prevent saturation and so forces both inputs to be equal.

As an example of this principle consider the inverting amplifier.



The operational amplifier input takes no current, so that $i_M = 0$

Hence $i_1 = i_f$

$i_1 = (v_{in} - v_M)/R_1 \qquad i_F = (v_M - v_{out})/R_F$

Hence $\dfrac{(v_{in} - v_M)}{R_1} = \dfrac{(v_M - v_{out})}{R_F}$

The negative feedback and infinite gain force $v_M = v_P$, but $v_P = 0$ so that v_M is forced to 0.

Thus $\dfrac{v_{in}}{R_1} = -\dfrac{v_{out}}{R_F}$ or $\dfrac{v_{out}}{v_{in}} = -\dfrac{R_F}{R_1}$

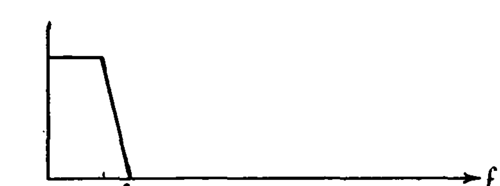
Notice that the inverting input is held at 0 V: for this reason it is said to be a virtual earth although it is not physically connected to earth. It is also important to remember that no current can flow into this virtual earth because it is the input of the operational amplifier.

The principle that both inputs of a high-gain operational amplifier are at equal potentials is not limited to the configuration shown in the circuit given above. The virtual earth arrangement is a special case where the positive input is held at earth potential. The general principle can and should be applied explicitly when the difference amplifier is being discussed with students.

3.8 Sampling rate (Syllabus section 3.4)

If a continuous signal is sampled as part of the process of converting it to a digital signal (or for any other reason) the sampling frequency must be at least twice the frequency of the highest frequency component present to allow the signal to be received without distortion. This requirement on the sampling frequency is known as the Sampling Theorem or Nyquist Criterion. Notice that concern is for the highest frequency present and NOT for the highest frequency required.

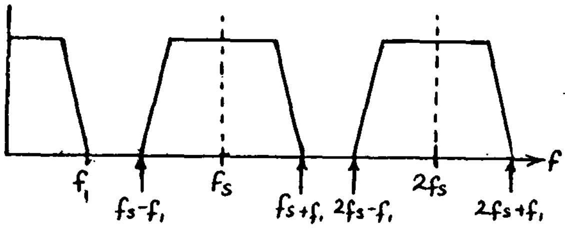
Consider a continuous, band-limited signal with the frequency spectrum shown below:



This is sampled at a frequency $f_s = 1/T_s$.

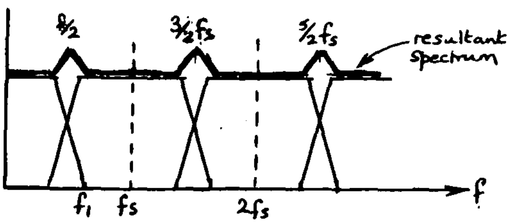
The process of sampling makes the frequency spectrum repeat about multiples of the sampling frequency. The sampling signal is a stream of impulses and has harmonics up to infinity, and the process of applying the sampling signal to the continuous signal has the effect of making the frequency spectrum repeat about the harmonics of the sampling frequency.

Note: the amplitude scaling is also affected by sampling



It can be seen from this spectrum that an ideal low-pass filter with cut-off frequency between f_1 and $f_s - f_1$ will completely recover the original spectrum.

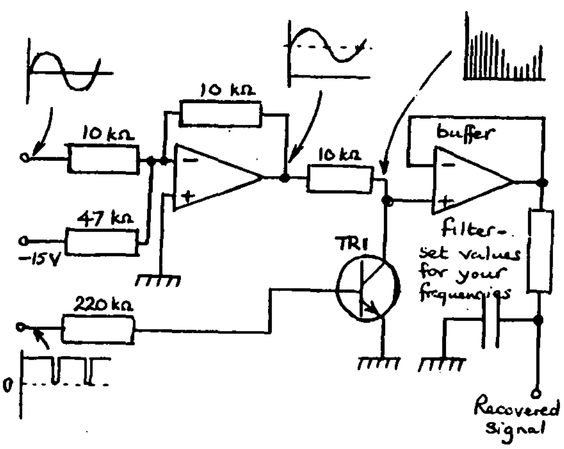
However, if f_s is reduced so $f_s < f_1$ the repetitive spectra overlaps:



The resulting spectrum is shown by the heavy line: notice that the original shape could not be recovered by filtering since the shape has been changed. This is known as aliasing distortion.

From the diagram above it can be seen quite clearly that the aliasing distortion extends well below $f_s/2$. This is why the sampling frequency must be greater than twice the highest frequency present, rather than twice the highest frequency of interest.

Aliasing can be demonstrated easily and cheaply in the laboratory. All that is required is is a sampling unit, a simple filter and an oscilloscope. At first sight it may seem difficult to make a sampling unit but in fact it is very easy. For the purposes of this demonstration the circuit shown below is quite adequate.

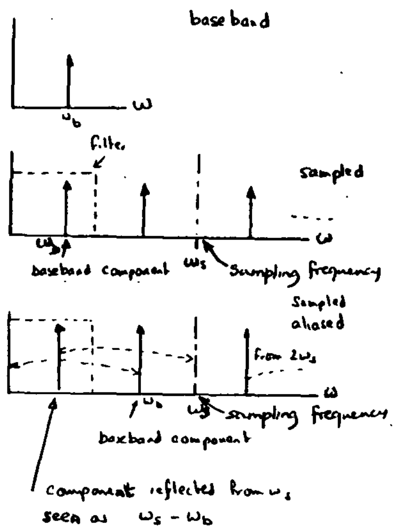


When transistor TR1 is OFF the input signal appears at the input to the operational amplifier but when the transistor is turned ON by the sampling clock the input is taken to zero. The op amp can be omitted but it is probably worth including because it does buffer the sampling unit and prevent the filter from loading the unit. A drawback with using the op amp is that the slew rate limits the frequency response that can be obtained and it is probably worthwhile using an op amp with a reasonably fast slew rate (such as a 741S) and keeping signal levels fairly low (of the order of a volt)

The sampling clock needs to have the sort of mark-space ratio that is shown on the diagram: a square wave should not be used.

To demonstrate aliasing keep the sampling rate fixed at some suitable frequency (2kHz is quite satisfactory). Use a sinewave signal for the input and start with a fairly low frequency, much lower than half the sampling frequency. Note the sampled siganl that appears at the output of the sampling unit and the recovered signal at the output of the filter. Increase the signal frequency and notice that immediately after it becomes equal to half the sampling frequncy the recovered signal no longer matches the input frequency: in fact, as the signal frequency is increased further the recovered signal goes <u>down</u> in frequency.

The reason for this can be seen on the following frequency-domain diagrams. Once the signal frequency is greater than half the sampling frequency the filter recovers the component reflected about the first harmonic of the sampling frequency.



3.9 Servomechanisms (Syllabus section 5.1)

The servomechanism is included in this syllabus as an example of a control system which introduces many of the ideas of this section. Moreover, information about the servomechanism is readily available.

3.10 Channel Selection and Multiplexing (Syllabus section 4.1)

Candidates are expected to be able to explain what is meant by frequency-division multiplexing (fdm) and time-division multiplexing (tdm). This explanation need only be in qualitative terms.

However, candidates are also expected to realise that the modulating of radio signals onto different carrier frequencies is a process of multiplexing (fdm): there is one transmission medium and the radio signals are multiplexed into this one medium.

3.11 Frequency modulation (Syllabus section 4.5)

Frequency modulation is a very difficult topic and candidates are only expected to have a basic qualitative understanding of the subject and to be able to appreciate the advantages and limitations of f.m. They should also be able to sketch the time waveform of an f.m. signal where the modulating signal is a square wave.

The following mathematical notes are provided for the benefit of teachers as many textbooks are not very clear on basic principles.

At first sight it is easy to write the carrier signal as

$$v_c = V_c \sin (\omega_c t + \phi_c)$$

where

v_c = instantaneous value the total signal

and

V_c = the peak value

and it would seem that amplitude modulation is achieved by varying V_c in sympathy with the modulation and frequency modulation by varying ω_c.

This is not the case.

In fact we should write $v_c = V_c \sin (\Theta)$ where (Θ) is the instantaneous phase [we can only take the sine of an angle: $\omega_c t + \phi$ is a particular expression for Θ].

Frequency is the rate of change of phase so that the instantaneous frequency is $d\Theta/dt$: call this ω_i

Hence $v_c = V_c \sin (\int \omega_i \, dt)$

[It is only if ω_i is constant that this expression simplifies to $v_c = V_c \sin (\omega t + \phi)$]

In the f.m. the instantaneous frequency is varied.

If we consider modulation by a single frequency

$\omega_i = \omega_c + KV_m \sin (\omega_m t)$ where ω_c is the carrier frequency with no modulation present, K is a constant and ω_m is the modulation frequency.

Hence $v_c = V_c \sin (\int [\omega_c + KV_m \sin (\omega_m t)] dt)$

$$\text{or } v_c = V_c \sin [\omega_c t - \frac{KV_m}{\omega_m} \cos \omega_m t]$$

This is a complicated mathematical expression and will not be manipulated further here, although there are some points worth noting.

(i) KV_m/ω_m is known as the modulation index: it does not have any relationship with the modulation index for a.m. (American books often call this the deviation ratio, which is wrong and confusing as the deviation ratio is something else).

(ii) the change in carrier frequency depends on both V_m and ω_m.

3.12 Stepper Motors (Syllabus section 5.4)

Candidates will not be expected to answer questions on the physical construction or the physical principles of stepper motors, but they will need sufficient knowledge and understanding of these devices to be able to discuss the characteristics of both their input and their output. Teachers may find the monograph 'Stepping motors: a guide to modern theory and practice' by P P Acarnley published by the Institution of Electrical Engineers, No. 19 in the Control Engineering Series useful for reference.

3.13 555 Timers

Notes on this section will be added at a later stage.

4. Books

The following books have been used by teachers in conjunction with their courses in Electronic Systems, and found to be useful. Some, but not all, are suitable for students' use.

Texts written specifically for the 1975 syllabus for Electronic Systems. Four volumes: General Systems and Systems Components, Communication Systems, Processing Systems and Feedback Systems.	Electronic Systems Teaching Programme Feedback Instruments Ltd Crowborough, Sussex
A Practical Introduction to Electronic Circuits by Hartley Jones	Cambridge University Press ISBN 0521 29087 2
Digital Electronics by C E Strangio	Prentice Hall ISBN 013 212100-X.
Success in Electronics by Tom Duncan	John Murray
An Introduction to Semiconductor Electronics By Close and Yarwood	Heinemann (1982)
Inside the Micro by D L Thompson	Unilab
Operational Amplifiers by G B Clayton	Butterworth
Beginners Guide to Radio by G J King	Newnes Butterworth
Beginners Guide to T.V. by G J King	Newnes Butterworth
Beginners Guide to Audio by I R Sinclair	Newnes
Understanding Communications Systems by D L Cannon	Tandy

Engineers Notebook by F M Mims	Tandy
Adventures with Digital Electronics by Tom Duncan	John Murray
Electrical Transducers for Industrial Measurement by P H Mansfield	Butterworths
The Wealth of Information by T Stoair	Methuen
Practical Electronic Building Blocks by R A Penfold	Babani
The Mighty Micro by C Evans	Gollancz
Cybernetics Simplified by A Porter	English Universities
The Intelligent Eye by R L Gregory	World University
Eye and Brian by R L Gregory	World University

5. Equipment

There is no prescribed list of essential equipment, and the range of practical work done will depend on what is available and the teaching approaches being used. Teachers are advised, however, to include in their courses practical work representing all sections of the content syllabus.

As indicated in Section 2.4 the texts prepared for this course by Essex University and published by Feedback Ltd do contain a series of experimental assignments specifically developed for the course. Teachers are advised to refer to these texts for ideas and suggestions. Apparatus for this series of experiments is manufactured by Feedback Ltd. Printed Circuit boards for similar apparatus are available through the Microelectronics Education Programme (MEP).

The following pages are photoreduced copies of the main parts of the assessment forms ES1 (the Project Brief), ES2 (the candidate list), and ES3/4 (the marking scheme and mark sheet).

Project Briefs for Electronic Systems are normally approved by the teacher but not submitted to the Board's Moderator for approval. However, certain types of projects do require prior approval by the Moderator. For detailed information refer to the notes in the Coursework Assessment booklet, ES3/4.

This Project Brief is: approved

not approved

Comments: ____

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Signed: ....
(Moderator)

Date: ....

NOTE

Approval by the Moderator indicates that the project is appropriate for the examination in Electronic Systems but does not indicate that every detail in the Brief is necessarily correct or appropriate.

In making a final assessment of the project, the initial brief will be taken into account.

DATE OF EXAMINATION

....
(Month)

....
(Year)

THE ASSOCIATED EXAMINING BOARD
for the General Certificate of Education

ELECTRONIC SYSTEMS

Advanced Level

PROJECT BRIEF

SCHOOL/COLLEGE: ____

CENTRE NUMBER: ____

CANDIDATE EXAMINATION NUMBER: ______________________________

CANDIDATE'S SURNAME AND INITIALS: ___________________________

Before completing this Project Brief you should read carefully through the project assessment form which indicates the criteria on which your work will be assessed.

The purpose of completing this brief is twofold.

1. It encourages you to consider carefully the nature and conduct of your project in order that it may be sensibly planned and organised.

2. It enables the assessor and moderator to compare what you have done and achieved with the planned intention, which is part of the scheme of assessment for the venture.

TEACHER'S DECLARATION

I confirm that this Project Brief has been prepared by the above candidate.

Signed: ....

Date: ....

1. What is the title of your project?

2. Briefly describe the problem to be solved.

3. State your proposed solution to the problem and the methods by which you intend to implement this solution. If the project involves a series of events in sequence, you should state what that sequence will be. Use block diagrams where appropriate to illustrate your specification, on the space provided on this form.

4. Give some indication of the types of materials and equipment you intend to use for the completion of your project.

provisional plans for overcoming them.

6. Make a list of the sources of information (including advice from other people) you have used, or think you may need to use, in your project activities.

7. Outline any test procedures you intend to apply to your completed system.

NOTES FOR GUIDANCE OF CANDIDATES

The space available on the form is an indication of the amount of detail you are required to give. In exceptional circumstances, an additional sheet of plain paper may be added if enough space is not available, and this extra sheet must have your name on it and be firmly stapled to this Project Brief.

In completing this Project Brief you should also consider what you are expected to do for the final report on your project. Your teacher or tutor will show you a copy of the Project Assessment Scheme that will be used to mark your project at the end of the course.

When the report is written make sure that your report is clear and easy to understand. Comment on the difficulties you encounter as well as those parts that succeed.

You are expected to consult sources of information (data sheets, excerpts, etc.), and mention them in your report. You will be marked on what you have done with this information, not on the sheer quantity of facts and information you present in the report.

In completing Sections 3 to 7 you will be putting down ideas about your project. Some of them may work, others may not, so you will probably have to make changes. Where major changes are necessary in the way you carry out the project, you should make detailed comments about the reasons in your project report.

ES2

ASSOCIATED EXAMINING BOARD

for the General Certificate of Education

ELECTRONIC SYSTEMS

Advanced Level

Centre Number .... Centre Name ....

Centre Address ....

.... Centre Telephone Number ....

Name of Teacher in charge of Electronic Systems ....

Month and Year of Final Examination ....

I am enclosing Project Reports for the candidates listed below.

Signed .... Date ....

Candidate's Name	Project Title	For Moderator's Use Only

If there is any special information of which the Moderator should be aware, please comment on a separate sheet of paper and attach the sheet to this form.
If candidates have entered for the subject but not submitted a Project Report, include their names in the list and write "no project submitted" in the Project Title column.
Send the top two copies, with the Project Reports, to the Moderator. Retain the third copy for reference.

1983

THE ASSOCIATED EXAMINING BOARD

for the General Certificate of Education

ELECTRONIC SYSTEMS (658)

ADVANCED LEVEL

COURSEWORK ASSESSMENT

LABORATORY ASSIGNMENTS AND PROJECT ASSESSMENT

This form contains notes for guidance on coursework and for Electronic Systems, instructions for the assessment of laboratory assignments and projects, the assessment scheme and an assessment sheet. Each assessment sheet is for one candidate and is perforated so that it can be detached from this form and attached to the candidate's work. One of these forms will be required for each candidate entered. It is expected that candidates will be familiar with the requirements of the assessment scheme and teachers are encouraged to let candidates see copies of this form at the time when the work is being planned.

GENERAL

In Electronic Systems, experimental work is seen as a very important component of the course and, accordingly, the coursework component of the examination carries 20% of the marks available for the examination. The assessment of practical work is in a form that should allow for discrimination between candidates with a flair for the subject, as well as discrimination between less able candidates, to be achieved. To this end, coursework assessment comprises two separate components:

(a) an overall assessment of candidates' performances in practical investigations assigned to the candidate by the teacher during the latter part of the course (last year of the course), the assessment being based on scrutiny of candidates' laboratory notebooks (log books) and the teacher's observation of the students' laboratory work;

(b) an assessment of candidates' performances on two projects involving the production of detailed reports for assessment purposes, undertaken during the last year of the course. *With prior approval by the Board*, one longer project covering more than one major aspect of the syllabus will be accepted in place of the two short projects. The two projects should be chosen in such a way as to enable the development and demonstration of different skills and knowledge. This will most readily be achieved by the choice of topics from separate areas of the syllabus. Where a single project is to be considered in place of two this topic should be sufficiently wide ranging also to meet this requirement.

PROJECTS

For the purposes of the Electronic Systems course a project is an exercise of sufficient scope, depth and detail to allow the candidate to make positive contribution to the planning and conduct of the work; to permit consideration of alternative strategies, designs or techniques; to make considered choices on the basis of a sensible appraisal of the alternatives and then to evaluate the outcome in terms of the intended and actual achieved objectives.

A project may be related to a design problem where an artefact is designed by the student, constructed, and evaluated in terms of desired performance. A project in which the student merely undertakes the construction of an artefact using a purchased kit or an unmodified circuit from a magazine is inappropriate at this level. However, it is possible that a thorough evaluation of such a system could be appropriate, in which case the assessment should relate to the evaluation and not to the construction. Where such circuits are used the source should be clearly identified in the report.

A project may be an investigation of the performance of a device or system where a particular assemblage of equipment and/or technique must be chosen from alternative possibilities.

The development of computer software is not of itself acceptable unless it relates to a particular problem or situation which is relevant to the study of the A-level Electronic Systems course. (See note on page 4.)

Exercises which involve the production of a dissertation based on a library book research exercise are not in general permissible.

It is expected that the projects submitted as part of the coursework requirement will be undertaken by students during the latter part of the course. A project will normally require four weeks of classroom time for its completion. This is equivalent to 20 hours of productive laboratory work, time for planning, preparation and report writing being additional to the 20 hours

It is of the utmost importance that all projects should be carried out by candidates on an individual basis, and each candidate should carry out practical work and produce a written report that is clearly the result of his/her own efforts. In cases where candidates wish to conduct projects of a similar nature, centres should ensure that the candidates involved undertake completely different aspects of the area of study to be investigated such that, in the written report, the candidate can demonstrate that he or she has undertaken work that is clearly identifiable as his/her own.

The assessment of the candidates' work will depend on the success of the exercise and the candidate should be advised to attempt a problem whose solution may be completely defined within the limitations of available time and resources. Complex projects which are likely to be incomplete or partially successful should be discouraged. However, the candidate should be encouraged to choose a problem which allows adequate scope for originality, ideas research, and whose solution is not so clear and well defined as to deny the opportunity for initiative.

In order to provide a clear basis for the work to be undertaken the candidate is required to complete the "project brief" on the proforma supplied by the Board to each candidate. These "project briefs" are not required by the Board in advance of the submission of project work but should be attached to each project report. This procedure will obviously benefit the candidate by giving encouragement to embark upon a well organised endeavour, and will assist in the process of moderation.

All project reports should be accompanied by at least one photograph illustrating the system constructed or assembled. Photographs which largely feature the candidate and not the work undertaken are not useful. The project reports of all candidates must be submitted to the Board. Centres must be able to demonstrate to a visiting moderator the nature of the practical materials used in the conduct of the project work. Where a hardwired system was constructed it will be that artefact itself. In the case of the use of basic modular equipment and/or breadboarding with general test equipment these should be available in order that the manner in which they were used may be discussed. The students' laboratory notebooks (log books) are not required by the moderator but must be retained by the centre and be available for inspection until the completion of the examination period.

LABORATORY ASSIGNMENTS

Electronic Systems candidates are expected to have undertaken laboratory work in Electronics as a regular part of their learning programme. The choice of the experimental topics and the method of working is the responsibility of the centre concerned. However, this work should incorporate two aspects:

(a) guided experimentation intended to develop the candidates' knowledge and understanding of fundamental concepts and techniques;

(b) the presentation of problems or further investigations which require the students to apply their newly learned ideas and techniques.

These two aspects of normal coursework develop the skills and abilities which the student is expected to demonstrate in the project work.

A detailed report is not required from an individual in-course experiment, but records of the experiments should be kept. The record should include an outline of the work, the procedures, results and deductions from the results, practical difficulties encountered, references to texts, etc.

The assessment of this work should depend both on the record in the report book and the teacher's knowledge of the conduct of the candidate during practical sessions in the course.

ASSESSMENT OF PROJECTS

The project is to be assessed out of a total of 34 marks. The marks are to be allocated under the following criteria.

GROUP	CRITERION	MARKS
(i)	Planning	6
(ii)	Organisation	2 + 3 = 5
(iii)	Practical Procedures	4
(iv)	Quantitative Work................	3
(v)	Evaluation.......................	5
(vi)	Initiative and Originality	5
(vii)	Written Communication...........	6

METHOD OF ASSESSMENT OF THE CRITERIA

Assessment is based on a series of questions about the candidate's work. The questions are arranged in various groups according to the criterion being tested.

The questions in each group are graded, each question representing a higher level of achievement than the preceding question in that group.

The assessment schedule assumes that the work conducted is genuinely of a level and scope adequate for a candidate in an advanced level practical subject examination. If this is not the case careful attention should be paid to the assessment in questions where words such as "significant, complete, most, adequate" ensure that the question may not be affirmatively answered if the work is not of a suitable content or level.

To assess a particular project, the teacher, on the evidence of the artefact, project report and his knowledge of the work of the candidate, will answer the questions in turn. If the answer is 'yes' to a particular question, award 1 mark in the appropriate column, and proceed to the next question in that group. If at any stage a 'no' answer is recorded, the marks awarded for that particular question *and remaining questions in that group* are zero, and the teacher will proceed to the next group of questions.

The teacher is requested to add brief comments in the space on the assessment form where they will assist the Moderator in understanding why a particular mark has been awarded or withheld.

The assessment questions are on page 6 and the marks are entered on page 7.

ASSESSMENT OF LABORATORY ASSIGNMENTS

The assignments are to be assessed out of a total of 17 marks. This mark will be multiplied by two and added to the project marks to give a total out of 102. The marks for the assignments are to be allocated under the following criteria.

GROUP	CRITERION	MARKS
(I)	Experimental Competence.........	3
(II)	Knowledge and Understanding	6
(III)	Analysis.........................	5
(IV)	Written Communication...........	3

are automatically zero, meaning that no marks can be scored in these groups and the maximum mark for the assignments is 5 (if all questions in Group (III) are answered 'yes'). Candidates who fail the examination and expect to re-take the examination in the following year must carry out additional laboratory work in the extra year unless permission has been given by the Board for the previous marks to be carried over.

SUBMISSION OF ASSIGNMENTS AND PROJECTS

The Project Reports and Laboratory Notebook for every candidate must be assessed by the teacher and then the Project Reports *but not the Laboratory Notebooks* should be sent to the Moderator together with assessment forms and a copy of form ES2, to reach the Moderator **not later than** 15th May in the year of the examination. The Board will notify Centres of the name and address of their Moderator by 1 April. Project Reports WILL NOT BE RETURNED. Centres or candidates requiring copies of their reports should make such copies before submitting the Report. The Board will not accept photocopies and requires the original Report to be submitted.

NOTE ON ORIGINALITY

Candidates are expected to find or think out solutions to practical problems for themselves, wherever possible. In Group (vi) of the scheme for assessing the projects, question (c) uses the word 'original'. This is intended to mean 'new to the candidate' rather than original in an absolute sense. A candidate who has provided on his or her own initiative a useful idea pertinent to the solution of the problem, by reading, consultation, application or inventiveness, can be awarded the mark in Group (vi) (c), assuming he/she has earned the marks in Group (vi) (a) and (b) as well.

NOTE ON COMPUTER PROGRAMMING

Producing and testing computer software is not in itself a suitable project exercise for A-level Electronic Systems. Where however the production of software is part of a wider project or where the program itself has some very direct relevance to the A-level course then it is acceptable. Examples which fall in this category include the following.

(i) The devising of a program for the control of a system which includes elements external to the computer itself. In such a case the generation and processing of the input and output signals to the computer each require detailed consideration as does the means by which this information determines the systems response.

(ii) The use of the computer to provide solutions to a systems design problem or the prediction of systems behaviour where the computer offers significant advantage over traditional methods of processing. In this case the project could include the production of the corresponding hardware, the response of which may be practically determined and compared to the expected result.

(iii) The use of the computer to model the behaviour of a system or of interacting subsystems.

Prior approval from the Board should be obtained for any programming exercises not falling into these categories.

NOTE ON INVESTIGATION OF SYSTEMS WHICH ARE NOT BASED ON ELECTRONICS

Exercises which involve the production of a dissertation based on a library book research exercise are not in general permissible. However, the study of biological, cybernetic or sociological systems forms a part of the syllabus and could form the basis of a project. In practice, the demands in time and insight upon the student for successful completion of such projects make success in such investigation difficult to achieve, or lead to such gross oversimplification that the result is misleading or unreal. Proposals for projects in this area are acceptable, but in all such cases the proposal must have the prior approval of the Board.

PROCEDURE WHERE PRIOR APPROVAL OF PROJECT PROPOSALS IS REQUIRED

Wherever prior approval is required for a project, the completed Project Brief (on the standard form ES1) should be submitted to the Board. Approval will be considered on the basis of this Project Brief. Such Project Briefs can be submitted any time from June in the year preceding the date of the examination but not later than 31st March in the year of the examination. To avoid problems if approval is withheld, Centres are advised to submit such requests for approval as soon as the nature of the project has been determined by the candidate.

Where prior approval IS given, the Board will advise, if necessary, on the way the marking scheme should be interpreted for questions which do not apply directly to such projects (eg Group iii).

CENTRE NO.

QUESTIONS FOR ASSESSMENT OF THE PROJECT

Use one booklet for each candidate: fill in the details across the top of pages 7 and 8.

Access the . project by placing 1 (yes) or 0 (no) in the space in Column 1 on page 7 adjacent to the appropriate question on page 6.

For the assignments turn this booklet over and repeat the procedure, filling in Column 2 on page 8.

Note that, in each group, once a question has been given zero all subsequent questions in that group are zero and you must go on to the next group.

				Column 1
GROUP (i) PLANNING 6 marks	(a) Does the report contain a clear statement of the problem?	(i)	(a)	
	(b) Does the report contain a specification of some facets of the problem and its likely outcome in clearly defined or quantitative terms?		(b)	
	(c) Does the report contain a specification of all significant facets of the problem and its likely outcome in clearly defined or quantitative terms and was the exercise of adequate scope?		(c)	
	(d) Does the report contain a statement of at least one realistic approach to the solution of the problem?		(d)	
	(e) Does the report include a consideration of realistic alternative approaches with a view to the selection of an optimum approach?		(e)	
	(f) Did the candidate produce a written outline of the proposed project (project brief) before the commencement of the project and is the project brief attached to the report?		(f)	
GROUP (ii) (A) ORGANISATION: USE OF MATERIALS 2 marks	(a) Did the candidate use a reasonable selection of available materials and equipment?	(ii) (A)	(a)	
	(b) Did the candidate use an optimum selection of available materials and equipment?		(b)	
GROUP (ii) (B) ORGANISATION: USE OF RESOURCES AND TECHNIQUES 3 marks	(a) Did the candidate identify and use a feasible selection of practical materials, equipment and techniques?	(ii) (B)	(a)	
	(b) Did the candidate identify and use an optimum selection of practical materials, equipment and techniques?		(b)	
	(c) Did the candidate use an optimum selection of materials, equipment and techniques in a sensible and coherent strategy?		(c)	
GROUP (iii) PRACTICAL PROCEDURES 4 marks	(a) Was the system employed assembled sensibly, competently and safely from the point of view of the user and of the equipment itself?	(iii)	(a)	
	(b) Could the circuit of the assembled equipment or system be reasonably easily traced and could it be readily investigated using test instruments?		(b)	
	(c) In the final event was the system reliable and free from malfunction?		(c)	
	(d) Was the system of good appearance and sound construction indicative of a fair degree of practical skill and organisation?		(d)	
GROUP (iv) QUANTITATIVE WORK 3 marks	(a) Has the candidate attempted to define and determine the performance of the system in quantitative terms?	(iv)	(a)	
	(b) Has the candidate measured or evaluated all the significant parameters required to define the performance of the system in quantitative terms and was the exercise of adequate scope?		(b)	
	(c) Has the candidate made a complete and thorough determination of the performance of the system?		(c)	
Group (v) EVALUATION 5 marks	(a) Has the candidate attempted to compare the performance of the system with the original specification?	(v)	(a)	
	(b) Is the candidate's evaluation of the performance of the system valid in most aspects?		(b)	
	(c) Is the candidate's evaluation of the performance of the system complete in every respect? See note below.		(c)	
	(d) Is the candidate's evaluation fully valid in every respect?		(d)	
	(e) Has the candidate recognised any limitations in the system constructed and suggested, where appropriate, means of overcoming these limitations?		(e)	
GROUP (vi) INITIATIVE AND ORIGINALITY 5 marks	(a) Has the candidate made at least some decisions pertinent to the solution of the questions arising from the planning and conduct of the project?	(vi)	(a)	
	(b) Did the candidate resolve most of the questions arising from the planning and conduct of the project?		(b)	
	(c) Did the candidate make any original contributions to the project?		(c)	
	(d) Was the candidate the main source of useful ideas pertinent to the solution of the problem? See note below.		(d)	
	(e) Did the candidate take all the important decisions pertinent to the successful conduct of the project?		(e)	
GROUP (vii) WRITTEN COMMUNICATION 6 marks	(a) Has the candidate reported at least some of the major aspects of the development and progress of the project?	(vii)	(a)	
	(b) Has the candidate reported all the significant aspects of the development and progress of the project?		(b)	
	(c) Is the development of the project adequately illustrated by photographs and/or block, layout or circuit diagrams? See note below.		(c)	
	(d) Is the presentation of the report logical and are the illustrations neatly and carefully presented?		(d)	
	(e) Is the report clear, concise, free of unnecessary repetition and easy to understand?		(e)	

CANDIDATE'S NAME ....

....

TEACHER'S COMMENTS:

TEACHER'S DECLARATION

The assessments on this page and page 7 have been made by me. The work I have assessed is work done by the candidate and is entirely his own work except where acknowledged in his reports or noted by me in the space above.

Signed ....

Date ....

(Note: Candidates are expected to make reference to books and other sources of information, and to receive help from their teachers. They will not be penalised for so doing, but must acknowledge all references used and all help given. Marks are awarded for the use they make of information, not for the information itself.)

Moderator's Signature:

....

Date ....

duration (or equivalent laboratory work), in addition to the assessed project **AND** did the candidate conduct a significa[nt] proportion of the required experimental work in an effective and competent manner?

(b) Did the candidate conduct the work independently, needing guidance only with those difficulties requiring experience f[or] their solution?

(c) Did the candidate complete all of the experiments attempted efficiently and competently?

II				**GROUP II – KNOWLEDGE AND UNDERSTANDING** — **6 marks**
	(a)			(a) *Did the candidate undertake, in the year immediately prior to the examination, six experiments each of at least four hou[r] duration (or equivalent laboratory work) in addition to the assessed project* **AND** in undertaking the experiments did th[e] candidate display, in at least half of the work undertaken, sufficient understanding of the techniques and principles to carry out the work in a self-sufficient manner without the need for instructions in skills which a candidate should have mastered before the work in question was undertaken?
	(b)			(b) Did the candidate display, in most of the work undertaken, sufficient understanding of the techniques and principles to carry out the work in a self-sufficient manner without the need for instructions in skills which a candidate should have mastered before the work in question was undertaken? ("most" means at least five of the six experiments or an equivalent proportion of whatever work has been assessed).
	(c)			(c) Was the candidate's final understanding of the techniques and principles demonstrated in all the assessed work sound in most respects?
	(d)			(d) Did the candidate's understanding and appreciation of the principles and techniques demonstrated in this work extend beyond the immediate experiment brief and has the candidate indicated this in the reports or during the conduct of the wo[rk]?
	(e)			(e) Was the candidate's final knowledge and understanding of all the principles and techniques demonstrated in this work complete in all respects without exception?
III				**GROUP III – ANALYSIS** — **5 marks**
	(a)			(a) Has the candidate recorded results and findings for a significant proportion of the experimental work conducted?
	(b)			(b) Were these results and findings largely valid, complete and correct?
	(c)			(c) Has the candidate recorded results and findings for all the experimental work conducted?
	(d)			(d) Were all these results and findings valid, complete and correct?
	(e)			(e) As well as stating the obvious implications and findings of the analysis of the work completed, has the candidate suggeste[d] a use for the knowledge gained in a wider application or for the solution of a further problem?
IV				**GROUP IV – LABORATORY NOTEBOOK** — **3 marks**
	(a)			(a) Has the candidate written reports on at least six coursework experiments or their equivalent and are most of the significa[nt] aspects of the work included in these reports?
	(b)			(b) Are the reports clear, concise, easy to interpret and an accurate account of the candidate's work?
	(c)			(c) Do the reports include all significant aspects of the work undertaken, and are they a valid account of this work?
TOTAL MARK FOR COLUMN 2				
TOTAL MARK FOR COLUMN 1 (from page 7)				
SUM OF TWO TOTALS = FINAL COURSE-WORK MARK OUT OF 50				

This page is 'the wrong way round' so that in the booklet the project mark sheet can be printed on the back of the coursework mark sheet.

AEB

ELECTRONICS

Ordinary Level (080)

SYLLABUS, SPECIMEN PAPERS AND NOTES FOR THE GUIDANCE OF TEACHERS

The Associated Examining Board

INTRODUCTION

The Ordinary Level Electronics Syllabus was introduced in 1982. The Board recognised that, because there were several unusual features in this scheme, it would be necessary to provide supporting information for teachers. All that information has now been collected into a single booklet. This booklet contains an off-print of the syllabus, a copy of the 1983 question papers, "Notes for the Guidance of Teachers" and copies of the forms used in connection with the project (as used in 1984). "Notes for the Guidance of Teachers" includes detailed information on the conduct of the project and its assessment.

In using this booklet, please check page 2 for details of any amendments (and use the page to make a note of any amendments sent out by the Board). Details of the project assessment are amended from time to time (the syllabus will not change in 1986 or 1987).

CONTENTS

THE ASSOCIATED EXAMINING BOARD
Wellington House, Aldershot, Hampshire. GU11 1BQ
Telephone: Aldershot (0252) 25551

AMENDMENTS

These notes were prepared in September 1984. Later editions will include information on subsequent amendments on this page.

ELECTRONICS – 080

SYLLABUS – ORDINARY LEVEL

Two papers, one of 1½ hours and one of 2 hours, and a project.

Centres wishing to enter candidates for this subject should inform The Secretary General (A7) of the number of candidates not later than 15 October

INTRODUCTION

Electronics occupies a special place amongst the applied sciences. Rapid improvements in technology over the past decade have led to the introduction of electronic systems in more and more areas of present day society; in many instances electronic systems have changed, or will soon change, our way of life. Furthermore, modern technology makes it particularly easy to demonstrate important concepts in applied science using electronics.

This examination syllabus is intended to be a framework around which schools and colleges can build a teaching syllabus relevant to the needs and interests of their students. It should benefit those wishing to further their career in science generally, where they will certainly meet a great number of electronic systems, as well as those intending to pursue a career in electronics. The syllabus will also contribute substantially towards the general education of all candidates by developing their thinking and deductive capabilities and by increasing their awareness of the impact of electronics on modern society.

The approach taken in this syllabus is to treat the subject, as far as possible, on a systems basis. With this approach students are required to make use of their abilities in stating and solving a problem, in selecting the best realisation of a particular system from possible alternatives and in understanding how the component parts of a system interact to make the whole system meet its specification. Central to this approach is the concept of 'basic building blocks' and these blocks form the core of the syllabus. It is important that students should also appreciate that real electronic systems are not collections of idealised blocks but are made up from passive and active components, discrete transistors and integrated circuits. A review of the important properties of these components is therefore included although the approach taken is still to treat each component as part of a system: what it does is important, but no treatment is required of the physics explaining these properties.

In many schools and colleges this subject will be taken by candidates who are also studying physics. This syllabus includes basic work on electrical circuits that is also covered in O-Level Physics, but the approach will complement rather than duplicate the approach used in physics.

Aims

1. To show the importance of electronics in present day society.
2. To introduce systems concepts through electronics.
3. To introduce the process of system design.
4. To develop skills in the design, realisation and operation of simple electronic systems.

Objectives

At the end of the course a candidate should be able to demonstrate the following abilities:

1. Recall and comprehension: recall of technical terms necessary for a full understanding of the syllabus; knowledge of principles of electrical theory, behaviour of components and nature of circuits used in building blocks; relating of knowledge to familiar situations specified in the syllabus.
2. Application of the appropriate knowledge to new situations.
3. Problem solving: the ability to recognise, state, interpret and solve a problem and then to evaluate the solution.
4. Analysis and computation: the ability to use quantitative relationships in the analysis of circuits and of data.
5. Synthesis: the ability to synthesise a system to meet a specification, given a set of basic 'building blocks'.
6. Evaluation and judgement: the ability to choose the best solution to a specified problem given a set of alternatives.
7. Perceptive skill in the realisation of electronic circuits from circuit diagrams.
8. Manipulative skill: the ability to construct neat, functional and reliable circuits.
9. Deductive skill: the ability to identify faults in simple electronic circuits.
10. Appraisal: the ability to make a critical appraisal of electronics technology in its interaction with society.

Structure of the Examination

The examination will consist of two question papers and a project.

Paper 1 (40% of the total marks) will be of 1½ hours duration and will contain short answer questions all of which should be answered. These questions will assess mainly abilities 1, 2, 3, 4, 7 and 9.

Paper 2 (40% of the total marks) will be of 2 hours duration and candidates will be required to answer four questions. The paper will be divided into three sections. Section A will be based on Section 7 of the syllabus and candidates will be required to answer one question from this section. The questions in Section A may be in the form of three questions, one on each option, or of a single question with appropriate alternatives incorporated in the question. Sections B and C will each include three questions, and candidates will be required to answer one question from each section and a further question chosen from either Section B or Section C. This paper will assess mainly abilities 1, 2, 3, 4, 5 and 10.

The Project (20% of the total marks) will be teacher-assessed and moderated by the Board. It will assess abilities 3, 5, 6, 7 and 8.

Private candidates will also be required to complete a project but it will be assessed by the Board and such candidates will be required to attend at a pre-arranged time and place for an interview with the Moderator.

All candidates will be required to submit a Project Brief to the Moderator for approval. This submission should be made on a standard form obtainable from The Secretary General (A7), and should normally be returned to the Board by 30 November 1982.

Full details of the Project Brief approval procedures, together with additional information on the project, project assessment and the syllabus, are included in 'Notes for the Guidance of Teachers'. All teachers preparing candidates for this syllabus and all private candidates should obtain a copy of 'Notes for the Guidance of Teachers' by applying to The Secretary General (A7).

The units used in question papers will be those set out in the British Standards Institution publication 'The Use of Units' PD 5686: 1972, to which the Board's policy document 'The Use of Units' 5/DM refers. Electrical and Electronic circuit symbols used in question papers will be in accordance with BS 3939 and text symbols used will be in accordance with BS 3363. Further information on these conventions, and on the symbols and conventions which will be used in Logic diagrams, is included in 'Notes for the Guidance of Teachers'.

Figures in square brackets (e.g. [2.1]) in the syllabus are references to specific sections in 'Notes for the Guidance of Teachers'.

Syllabus	*Guidance Notes*
1. SAFETY	

This section is intended to make pupils aware of the dangers associated with electronic equipment and of the safety precautions needed when working with such equipment [2.12]. The section has been placed at the beginning of the syllabus to emphasise that what is required is a safety-conscious approach applied to the whole of this syllabus, rather than isolated knowledge of safety requirements.

Dangers of electricity	Candidates are expected to: (a) be able to describe the effects on the human body of an electric shock as the fault current is varied; (b) know how burns can be caused by electricity; (c) know how the environment affects the dangers of electricity.
First Aid	Candidates should know the procedures for dealing with a casualty in contact with live equipment, or one suffering from burns, or one who has stopped breathing.
Prevention of accidents	Candidates should be able to explain why the following precautions are necessary: (a) that no-one should work alone in a laboratory, that students must not work in a laboratory without proper supervision; (b) that all persons in a laboratory should know how to summon help in an emergency; (c) that mains plugs must be wired correctly, that proper strain relief should be provided for cables and that damaged cables should be replaced promptly; (d) that equipment should be disconnected from the mains before being worked on, that capacitors may hold a lethal charge even though the equipment is isolated.
Protective measures	Candidates should be able to: (a) explain the need for proper earthing; (b) explain the purpose and limitations of the following protective devices: fuses, earth-leakage circuit-breaker, isolating transformer; (c) discuss the advantages of using neons as mains-on indicators; (d) wire a mains plug correctly; (e) state that fuses and single pole isolating switches must be included in the line conductor of mains operated equipment and give reasons for these precautions.

2. *ELECTRICAL CIRCUIT THEORY*

Units, circuits, circuit laws, calculation based on these laws

The topics in this section should not be taught as a single block but as required by and in the context of other sections of the syllabus. This section is not set out in a teaching order.

Electric current	Candidates should know that a current is normally a movement of electrons but should also realise that movement of positive ions constitutes a current.
Currents at a junction: series and parallel pathways	The result of Kirchhoff's current law (i.e. that current flowing out of a junction is equal to the current flowing into it) should be known, but the law does not need to be named.
Conductors, insulators and semiconductors	Candidates should know the existence of these three groups of materials and be able to classify common examples.
Magnetic effect of a current	Candidates are expected only to know that the magnetic effect exists and appreciate its significance for relays, solenoids and transformers.
The ampere	Candidates will not be required to quote the formal definition in the examination.
Sources and their characteristics	Cells, mains driven power units and transducers as sources. Candidates should know the significance of source voltage, power rating, internal resistance, equipment costs and the capacity of cells.
The volt	Questions will not be set which require a definition in words.
Potential difference	Candidates should recognise that current flow is always associated with a potential difference.
Summation of p.d. around a circuit	The basic result of Kirchhoff's voltage law should be known but the law does not need to be named. Questions set will involve the use of the law only in the application to real systems or circuits as required by other parts of the syllabus. Specific 'Kirchhoff law' calculations will not be set.
Ohm's law	Candidates should be aware that Ohm's law applies only to metallic conductors at constant temperature.
Resistance: the ohm	Definition in words not required, but calculations based on the defining equation $v = iR$ may be set.
Resistors in series and parallel	For unequal resistors in parallel calculations will be limited to two resistors only, although the parallel combination may form part of a larger series/parallel arrangement.
Limiting ratings for practical resistors	Power rating, tolerance.
Measurement of voltage, current and resistance	Candidates are expected to be familiar with the practical use of meters and multimeters (moving coil and electronic types), including [illegible] tion, use within the limits of meter FSD, circuit loading (treated qualitatively) and limitations to accuracy. Details of meter construction, either mechanical or electrical, are not required other than those indicated below, and candidates will not be required to calculate shunt values.
Circuit of simple ohm-meter [2.1]	The basic ohm-meter circuit should be known and the consequences of reversed terminal polarity in some multimeters and of non-linear scale should be understood.
Digital measurement [2.2]	Candidates should understand in outline the principle of operation of single-slope analogue to digital conversion and be aware of the advantages and disadvantages of the digital voltmeter (DVM) compared with analogue instruments.
Power: the watt	Calculations based on the equations $p = iv$, $p = i^2R$, $p = v^2/R$ may be set.
Maximum power theorem	Candidates should know that for a source with a fixed internal resistance, maximum power is transferred into the load when the source resistance and load resistance are equal.
Capacitance	The capacitor should only be treated as a device which will store charge and will allow a.c. to flow.
Alternating voltage and current: amplitude, frequency, phase; peak-to-peak and r.m.s. voltages	Candidates should know that sine-wave alternating voltages and currents are usually measured in r.m.s. values, that peak = $\sqrt{2}$ × r.m.s. for a sine wave, and that power dissipation is calculated from r.m.s. values.

Waveforms

Use of the oscilloscope to show sine, square, ramp (timebase) and half-wave and full-wave rectified sine waveforms.

Transmission of information: analogue and digital representation of information

Candidates should understand that information can be represented by voltage or current amplitude, by frequency, by a binary state (e.g. state of a thermostat) or by a series of pulses as in binary numbers.

3. *ELECTRONIC COMPONENTS*

Resistors

Tolerance, power rating and preferred values. Candidates should understand why preferred values are used and may be asked to select preferred values in the examination.
(A list of preferred values on the E12 scale will be given in every question paper.)

Potentiometers: used as variable resistor or potential divider.

Preset and variable types.

Capacitors

The use of a capacitor to block d.c. but pass a.c. should be known. Candidates should understand: the differences in applications and uses of non-electrolytic and electrolytic capacitors including cost and practical range of capacitances; the significance of voltage rating and tolerance of a capacitor; the polarisation and leakage of electrolytic types. Details of construction are not required.

Transformers

Candidates may be expected to use the relationship:

$$\frac{\text{primary voltage}}{\text{secondary voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$$

Candidates should know that output power in an ideal transformer is equal to input power. Losses will be considered solely in terms of the source resistance of the secondary treated as a resistance in series with the secondary of an ideal transformer. All other losses or other forms of non-ideal behaviour are excluded, and candidates are not expected to be able to give details of the physical construction of practical transformers. The use of transformers for matching loads to sources is also excluded.

Switches

Candidates should be aware that switches may be multipole and/or multiway and should know the arrangements used for simple logical tasks such as dual control of stair lighting and reversing polarity.

The electromagnetic relay

Principle and applications only.

Diodes [2.3]

Diodes should be considered only in terms of their characteristic curve. No treatment of the solid state physics of the device is required. Turn-on voltages for silicon and germanium diodes should be known, and the significance of the peak inverse-voltage rating and forward-current rating should be appreciated.

Use of diodes in rectification: half-wave, full-wave and bridge rectifiers

Diodes employed in rectification circuits are assumed to have a constant forward voltage drop.

Zener diode

Use of idealised reverse characteristic of diode in regulation of a voltage supply.

Light emitting diode (LED)

Candidates should appreciate the significance of the forward-voltage drop and peak-inverse-voltage rating of a LED and be able to calculate appropriate circuit component values.
No explanation of the solid state physics is required. Candidates should know the advantages of the LED compared with the filament indicator bulb.

Use of LED in seven segment displays

Including means of indicating numbers by such displays and the use of a binary-code-decimal (BCD) to seven segment decoder.

Bipolar junction transistor [2.4]

Treated as a three terminal device. Candidates will be expected to understand the operation of the transistor in terms of I_B and I_C. No treatment of the solid state physics of the device is required.

Transistor characteristics

Questions will be set on n-p-n transistors only. Candidates should know that:

$$h_{FE} = \frac{I_C}{I_B}$$

	Constancy of h_{FE} in the active region should be assumed and candidates should know that h_{FE} has different values for different samples of transistors with the same type of number. Candidates should know how the transistor can be used as a switch (V_{CE} when the transistor is operating in saturation is assumed to be zero), and should know that V_{BE} for a silicon transistor biassed into the active region is about 0.7 volt.
Integrated circuits	Candidates should know that an integrated circuit is a silicon chip incorporating many transistors and associated circuits.

4. *PRACTICAL CONCEPTS*

Topics included in this section may be examined by questions in the written papers as well as being an element of project work.

Use of instruments: oscilloscope; multimeter; signal generator with sine wave and square wave outputs	Candidates should be familiar with the use of instruments in practical work and may be asked to describe standard practical procedures in the written paper. Familiarity with the function and adjustment of all controls normally provided on an oscilloscope (including timebase and Y-amplifier) is required.
Understanding of simple circuits	Candidates should be able to relate symbols and diagrams to real components and circuits.
Realisation of circuits from circuit diagrams	Given only a circuit diagram, candidates should be able to plan a layout for a simple circuit and construct the circuit on stripboard (Veroboard) and by direct wiring.
Mechanical and electrical reliability	Including importance of neat and logical arrangements and reliable solder-joints.
Colour coding of resistors	Candidates should be ablé to identify resistor values given the value for each colour in the colour code.
Recognition of numerically coded markings for values of components	Candidates should recognise the markings used according to the BS 1852 (such as 4R7 for 4.7Ω). Tolerance codings are excluded.
Use of multimeter to identify faulty components in simple circuits [2.5]	Faults will be limited to: resistors outside tolerance; capacitors short circuited; diode and transistor junctions not having a low forward and high reverse resistance; dry joints (open circuits).

5. *'BUILDING BLOCKS' FOR ELECTRONIC SYSTEMS*

This syllabus is based on a systems approach to electronics. One aim of the course is to develop the ability to construct electronic systems by connecting together electronic 'building blocks' (modules). A set of basic building blocks is listed in this section and candidates will be expected to have a knowledge of the overall function of each block sufficient for them to synthesise, in block diagram form, a required system and to interpret block diagrams of simple systems.

To be able to do this, candidates should understand that for interfacing:

(a) the output voltage levels of one block must be compatible with the input requirements of the next block;

(b) the current demand of an input must not exceed the supply capability of the previous one;

(c) the input resistance of a block must be the same as the output resistance of the previous one if maximum power transfer is needed and that if these conditions are not met, a matching device must be interposed.

Building Blocks

Voltage amplifier	
Analogue summer	Treated as a block that produces an output voltage equal to the algebraic sum of the inputs. Candidates should understand the difference between a summer and an AND gate.
Voltage comparator	
Ramp generator (integrator)	Treated as a block that produces a linear rising or falling output voltage for the duration of a constant input. Candidates will be expected to know that the slope of the ramp is proportional to the input voltage.
Astable multivibrator	Candidates will be expected to understand the meaning of the terms 'pulse width', 'repetition rate' and 'mark/space ratio'.

Logic gates: NOT; AND; OR; NAND; NOR. Combinational logic circuits [2.6]

The truth table for each of these gates should be known. Candidates should know that: AND can be implemented as NAND followed by NOT; OR can be implemented as NOT followed by NAND. Candidates should be able to: design an AND–OR logic circuit from a truth table; convert an AND–OR circuit to NAND–NAND; derive a truth table from a combination of logic gates. Minimisation of the number of gates, understanding of Boolean algebra, and explicit knowledge of De Morgan's theorem are not required.

Transducer

Treated as a block that converts a signal from one form into another, one of these forms being electrical.

Matching device

Candidates should be aware that transducers normally need a matching device and that the current amplifier is a special case of a matching device.

Power supply

6. *SYNTHESIS OF BUILDING BLOCKS*

Some of the 'building blocks' specified in the previous section are to be treated not only as complete units but also as assemblies of discrete components in order to establish the link between electronic systems and the devices, circuits and principles inherent in them. The building blocks to be treated in this way are listed again in this section with an indication of the detail required.

In each block specified in this section candidates should be able to associate the circuit with the function, to explain its behaviour in qualitative terms and to calculate component values to enable the circuit to fulfil a specified function. (All necessary data not indicated specifically in one or other section of the syllabus will be given in the questions).

Treatment is not required of the internal circuitry of those blocks included in Section 5 but not this section. In considering the implementation of the blocks in this section questions will only be set on circuits specified here.

Power supply

Candidates will be expected to draw the circuit of a power supply consisting of:
transformer (centre-tapped if appropriate); silicon diode rectifier (full-wave, bridge); smoothing capacitor; voltage stabilisation using zener diode. Candidates may be asked to sketch voltage waveforms at any point in the circuit and to explain the term regulation (load regulation only). Candidates may also be asked to explain how the value of load resistance affects the ripple in unregulated circuits.

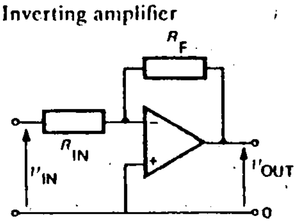
Logic circuits [2.7]

In practical situations where logic circuits are required it is assumed that integrated-circuit logic-gates will normally be used. However, candidates are expected to be able to explain the mode of operation of and perform simple calculations on logic gates constructed from discrete transistors. This section is regarded as the essential link between transistors and integrated circuits. The advantages of integrated circuits compared with circuits for the same function using discrete components should be appreciated.

Operational amplifier circuits [2.8]

The operational amplifier should be treated as an ideal differential amplifier (when operated within saturation limits determined by the power supply voltages) with a very large voltage gain. No knowledge is required of the internal behaviour of the operational amplifier or any other integrated circuit. Candidates will not be expected to memorise pin-connection numbers, nor know anything about compensation of offsets or bias currents.

(a) Inverting amplifier

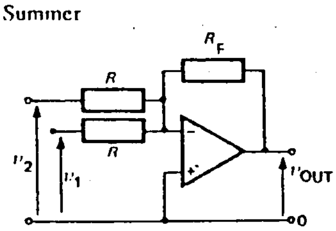


Candidates should know but do not need to be able to derive the equation

$$v_{OUT} = -\left(\frac{R_F}{R_{IN}}\right) V_{IN}$$

For simplicity the operational amplifier will always be shown without power supply connections and with the inverting terminal uppermost.

(b) Summer

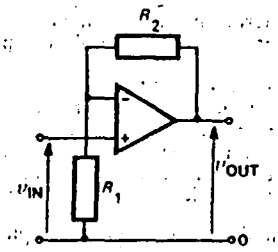


Candidates should know but do not need to be able to derive the relationship

$$v_{OUT} = -\left(\frac{R_F}{R}\right) (v_1 + v_2)$$

and understand the significance of the minus sign. Candidates may be asked to sketch an output waveform given a specific input. Questions may be set in which the input resistors have different values.

(c) Non-inverting amplifier

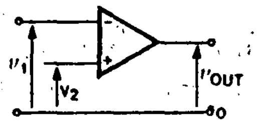


Candidates should be able to use but not derive the expression

$$v_{OUT} = \left(1 + \frac{R_2}{R_1}\right) v_{IN}$$

and to show that they understand the differences between the inverting and non-inverting configurations, including the input current drawn by each configuration. The unity-gain buffer will be treated as a special case of this configuration.

(d) Comparator



Candidates should know that if $v_1 > v_2$ the output will be close to the negative supply voltage and *vice versa*.

7. ELECTRONICS IN SOCIETY

Candidates should study the section on Information Representation and ONE of the three options, I (The Telephone System), II (Radio and TV) and III (Computing). See note [2.9].

Information Representation

Meaning of *digital* and *analogue* in representing information, and the relative merits of each

Including the use of a pulse train to represent a multibit number. Candidates should be aware of the high immunity to distortion of digitally coded information.

Examples of analogue representation

The carbon microphone giving current as the analogue of information. The crystal microphone giving voltage as the analogue of information. The analogue voltmeter giving an analogue representation of electrical information.

Examples of digital representation

In addition to the representation of numbers by binary and BCD code, candidates should understand the inherently digital signal system of the common thermostat, of the common 'ignition' warning system in a car, and of automatic traffic lights.

Transmission of information

Block diagram of a communication system comprising information source, modulator, transmitter, propagation medium, receiver, demodulator, receptor of information. Candidates should know how these blocks relate to the particular systems they study in options I, II or III.

Modulation

Candidates will be expected to understand that many channels of information can be represented on a single carrier by modulation, and that modulation can be by amplitude or frequency variation.

Information storage

Candidates should be able to discuss the relative merits of memory systems, including non-electronic means of storing information such as words, numbers, punched cards and gramophone records.

Option I: The Telephone System

Transmission and reception of verbal information by microphone, earphone, and power source

Candidates should understand the basic principles of operation of the carbon microphone and magnetic diaphragm earphone.

Signalling system for automatic connection of calls, using pulse (dialled) coding.

Candidates should understand the operation of the dial as a means of producing a train of pulses and should understand in outline how these pulses are used at the exchange for automatic selection.

The telephone system in society

Candidates should be able to:
(a) give an outline of the numerical growth of the service;
(b) state the major developments within the system: automatic exchanges, international links, STD, multiplexing, electronic switching, use in association with VDU, computing equipment etc. for data transmission, microwave links, optical fibres;
(c) recall the determinant reason for each of these developments;
(d) describe the basic function of Prestel;
(e) list the principal users of the telephone service: commerce, journalists, private individuals;
(f) discuss the effects the telephone service has had on these users since its inception;
(g) discuss the possible effects of recent developments in the system.

Option II: Radio Communication

Electromagnetic waves [2.10]:
(a) velocity, frequency and wave length and their relationship
(b) properties: electrical and magnetic components; vertical and horizontal polarisation
(c) radiation and reception

Candidates should know the frequency spectrum, characteristics and use of LF, MF, HF, VHF, UHF and microwaves. Candidates should understand in simple terms the propagation characteristics as they determine the use made of each part of the spectrum.

Candidates should know that electromagnetic waves can be radiated and received by any conductor. Candidates should know why the half-wave-dipole aerial is commonly used for transmission and reception and should be able to discuss the significance of its length in practical use.

Amplitude modulation

A simple understanding of amplitude modulation is required in terms of its waveform, bandwidth and sidebands, and its demodulation by means of a diode detector.

The superheterodyne principle

Block diagram of superhet, comprising mixer, local oscillator, I.F. stages, detector, A.F. amplifier.

Use of radio for communication and mass entertainment

Candidates should be able to recall the main uses of radio:
(a) for communication by public services;
(b) broadcasting news and entertainment;
(c) education;
(d) advertising.

Candidates should be able to state reasons for the use of radio rather than telephone for communication in service organisations.

Importance of television in society for communication, entertainment, monitoring, surveillance, advertising, and data transmission

Candidates should be able to recall the main uses of television:
(a) communication;
(b) monitoring and surveillance;
(c) broadcasting news and entertainment;
(d) education;
(e) advertising;
(f) data display.

Candidates should be able to:
(a) discuss the relative advantages and disadvantages of radio and television as media for journalism and entertainment;
(b) appreciate the economics of mass production in the electronics industry in general and television equipment in particular.

Current developments: Teletext

Candidates should be able to discuss the possible role and market for Teletext.

Option III: Computer Systems [2.11]

Basic computer operations

Candidates should be able to:
(a) represent positive denary integers in binary form;
(b) state the truth table for a full adder and design the logic circuit for such an adder;
(c) draw a block diagram showing how to connect full adders (as blocks) to add two positive binary numbers;
(d) draw a flowchart for software multiplication based on the 'shift and add' technique;
(e) explain the function of the following registers:
accumulator; program counter.

Microprocessor systems

Candidates should be able to:
(a) draw a block diagram of a microprocessor system consisting of the following blocks:
processor, clock, memory, input/output interface;
(b) describe the function of the following types of peripheral:
teletype, alphanumeric VDU, cassette tape recorder as the simplest form of backing store;
(c) describe the differences in use between the following types of memory:
RAM, ROM, PROM, EPROM;
(d) explain how the 'data bus', 'address bus' and 'read/write line' are used in a microprocessor system;
(e) explain how a 'tri-state' output stage makes it possible to connect an integrated circuit to a bus.

Use of computers

In discussing applications of computers candidates should be able to distinguish between the following types of use:
(a) batch processing of scientific programs;
(b) interactive processing of scientific programs;
(c) data processing (e.g. stock control);
(d) process control ('automation').
In each case candidates are expected to know whether a main-frame computer, a mini-computer or a microprocessor would be the most appropriate.

Social impact of the computer; developments in computing based on increasing use of microprocessors

Candidates should be aware of:
(a) the limiting factors in electronics technology which determine the range and scope of feasible applications;
(b) discuss the implications, both desirable and undesirable, of: large scale use of microprocessors

For Examiner's use only

THE ASSOCIATED EXAMINING BOARD
for the General Certificate of Education

June Examination, 1983 – Ordinary Level

ELECTRONICS

Paper 1 **080/1**

Monday, 6 June, 2.00 p.m. to 3.30 p.m.

1 hour and 30 minutes allowed

1. *Write in the space provided on this page:*

   (a) *your initials and surname in block letters,*

   (b) *the number of your examination centre (from your statement of entry),*

   (c) *your own candidate's number (from your statement of entry).*

2. *Open the flap at the back of this book and enter details (b) and (c).*

Answer all *questions in the spaces provided.*
In calculations, omission of working may lead to loss of marks.

The approximate number of marks allocated to each question or part of a question is shown at the end of each question. This paper carries 40% of the marks for the examination.

Data: The scale of preferred values is:

1.0	1.2	1.5	1.8	2.2
2.7	3.3	3.9	4.7	5.6
6.8	8.2			

The colours in the resistor colour code correspond to the following values:

Black	:	0	Green	:	5
Brown	:	1	Blue	:	6
Red	:	2	Violet	:	7
Orange	:	3	Grey	:	8
Yellow	:	4	White	:	9

[Turn over

1. List the following materials in the order of their electrical conductivities, with the best conductor first and the poorest conductor last:

Iron

Polythene

Silicon

Silver

Best conductor ....

....

....

Poorest conductor .... *2 marks*

2. Draw the circuit symbol for each of the following electronic components:

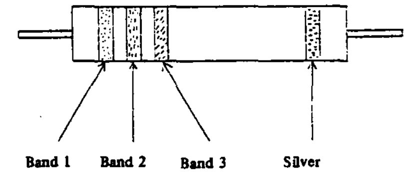
<u>Component</u>	<u>Symbol</u>
Variable resistor	
Light dependent resistor	
Electrolytic capacitor	
Ammeter	

4 marks

3. The label on a packet of resistors reads:

5k6 ± 10%

State the colour of each band on the resistors in the packet:



Band 1 ....

Band 2 ....

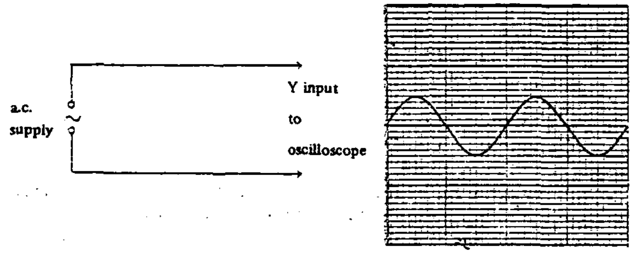
Band 3 ....

If you need to purchase a resistor of a similar type having approximately half this resistance what colour bands would you expect to see on the resistor you buy?

Band 1 ....

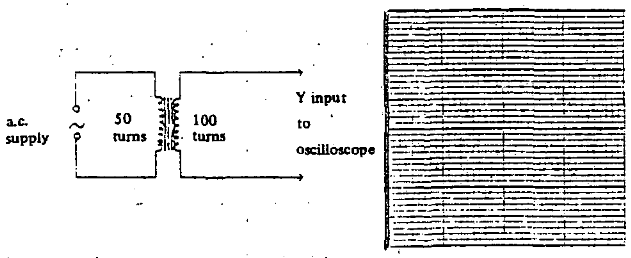
Band 2 ....

Band 3 .... *5 marks*



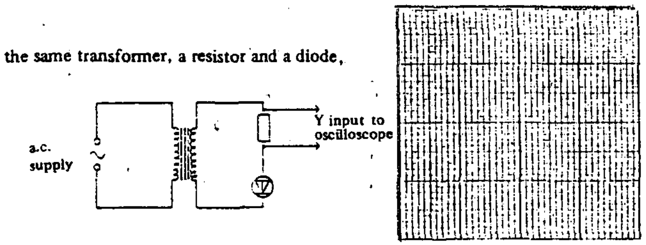
If the adjustment of the oscilloscope remains unchanged draw the trace that you would expect to see when the a.c. supply and the oscilloscope are connected to:

(a) a transformer with a primary coil of 50 turns and a secondary coil of 100 turns,



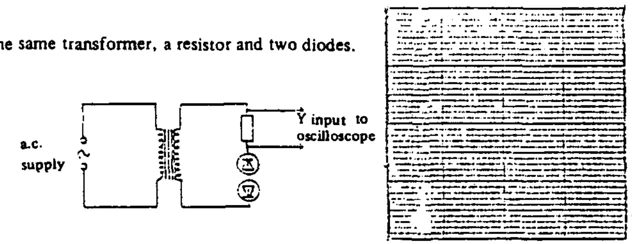
3 marks

(b) the same transformer, a resistor and a diode,

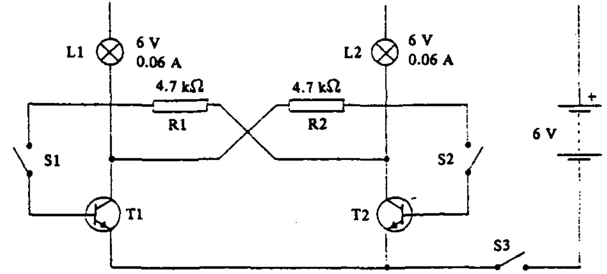


3 marks

(c) the same transformer, a resistor and two diodes.



1 mark



(a) What happens to lamps L1 and L2 when the switch S1 is closed?

.... *1 mark*

(b) Explain your answer to (a) by explaining the action of the circuit.

....

....

.... *3 marks*

(c) What happens to lamps L1 and L2 if switch S1 is kept closed and switch S2 is also closed?

.... *1 mark*

(d) Explain your answer to (c) by explaining the action of the circuit.

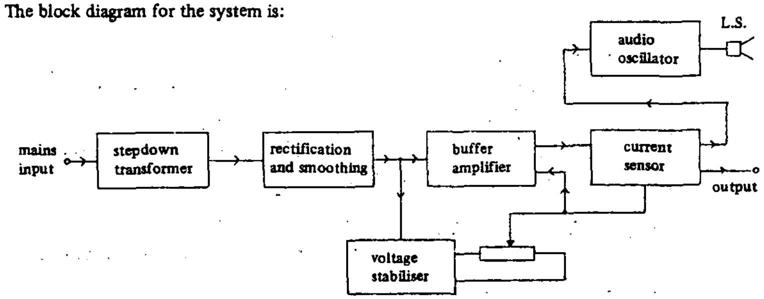
....

....

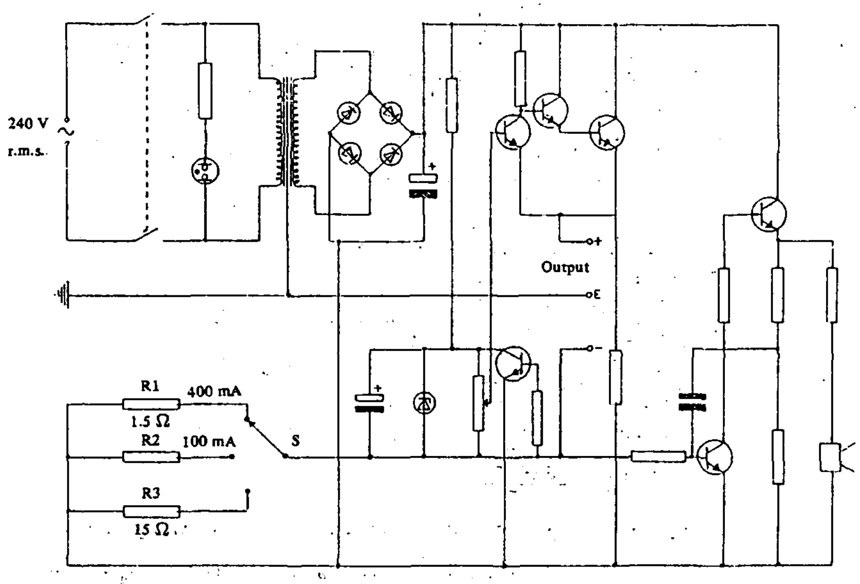
.... *4 marks*

6. One interesting feature of a recently published design for a 0 – 12 V d.c. power pack was an audible overload alarm and the fact that the current at which this alarm is triggered could be set by a switch.

The block diagram for the system is:



The circuit diagram is:



(a) On the circuit diagram draw a box, labelled (a), to indicate the part of the circuit that is included in the second block (rectification and smoothing) of the block diagram. *2 marks*

(b) On the circuit diagram draw another box, labelled (b), to indicate the part of the circuit included in the block (audio oscillator) at the top of the block diagram. *2 marks*

When the voltage at switch S reaches a set level, the overload alarm is triggered. The switch is used to select the current at which this happens. If the resistor R1, 1.5 Ω, is selected for connection into the circuit the limit is 400 mA.

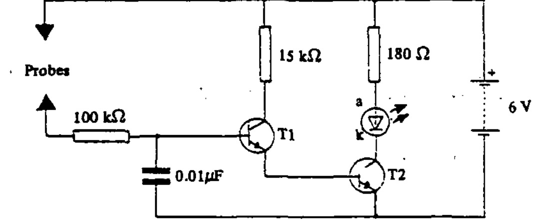
(c) Calculate the value of the resistor R2 if the current limit when it is connected into the circuit is 100 mA.

Resistor R2 is .... Ω *2 marks*

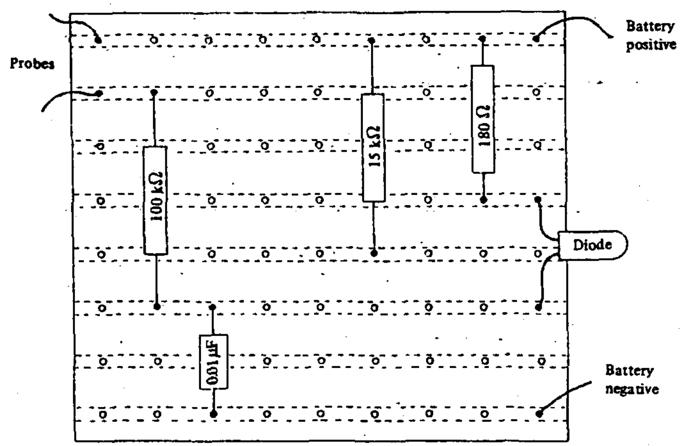
(d) Calculate the current limit when resistor R3, 15 Ω, is connected into the circuit.

current limit through R3 is .... mA. *2 marks*

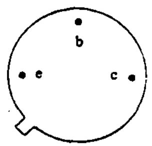
(e) The neon indicator in the circuit is not in the best position for maximum safety. Change the circuit diagram to show a better position for it to be connected. *1 mark*



Someone decided to assemble this circuit on a piece of stripboard. The partly assembled circuit **(top view)** is shown in this enlarged diagram:



The transistors to be connected to the stripboard look like this when viewed from the **underside**:



(a) Show how you would complete the assembling of this circuit by adding to the above stripboard diagram:

(i) the two transistors, clearly labelling each of the transistor leads,

(ii) a label 'X' to show the point where a break would have to be made in one of the copper strips on the underside of the board,

(iii) a label 'a' (anode) and a label 'k' (cathode) to show the correct connections of the diode. *8 marks*

.... *1 mark*

(c) Suggest one simple test that could be done after assembly to see if the device works:

....

.... *2 marks*

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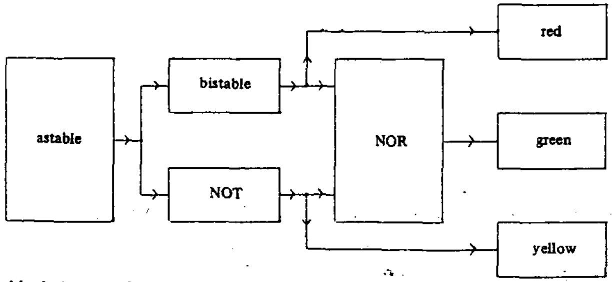
[Turn over

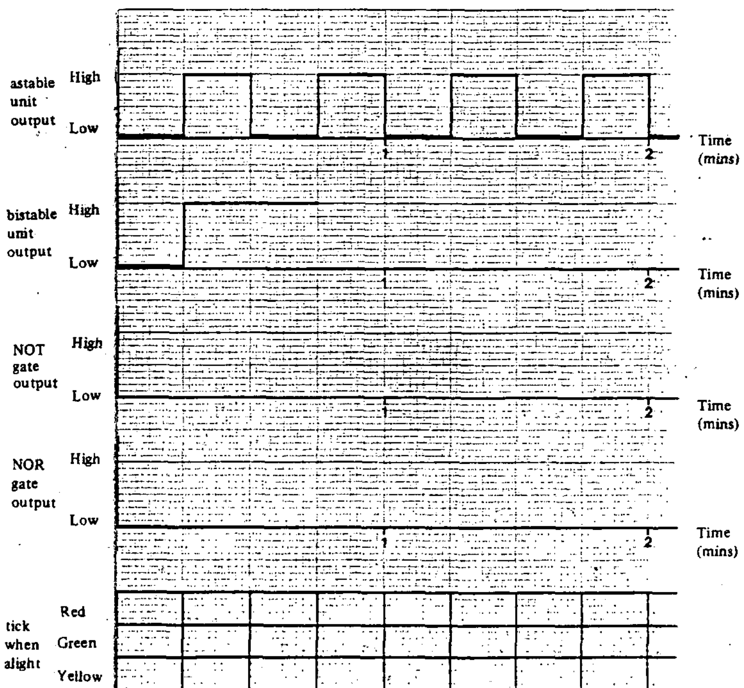
8.



In this block diagram the astable unit has an output producing square waves with an equal mark/space ratio. (See graph below).

The bistable unit changes the state of its output, either from low to high or from high to low, whenever it receives a positive going signal, that is a signal going from low to high.

(a) Complete the following graphs showing the outputs from the bistable unit, the NOT gate and the NOR gate and how they are related in time.



6 marks

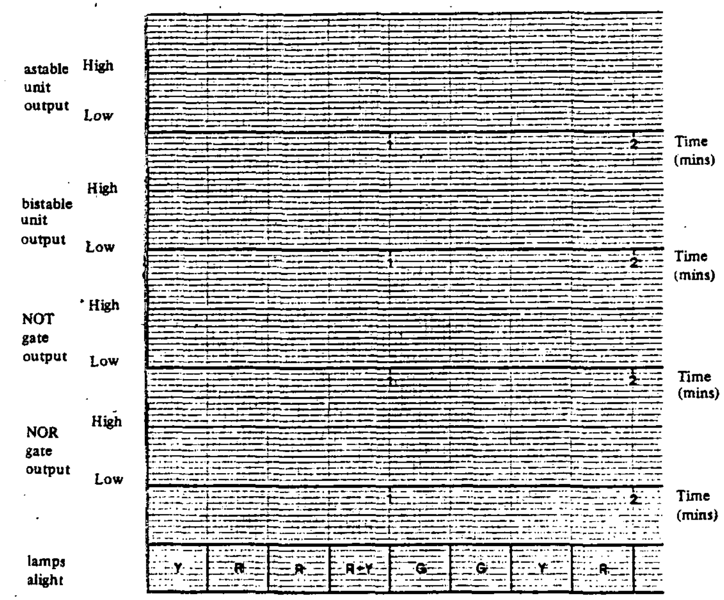
(b) The three blocks labelled red, green and yellow in the block diagram are coloured lamps which light when they receive a high signal.

Indicate the sequence in which the lamps light by ticking the appropriate boxes below the graphs in (a) above.

4 marks

(c) With lights in this sequence it would be helpful if the yellow light was only on for a ¼ minute at a time but the red and green lights, when alight on their own, were on for ½ minute at a time.

Show, by drawing graphs, how the outputs of the various units and gates would have to change to do this. *To help you in this the light sequence is shown below the graphs.*



8 marks

[Turn over

10 Ω per kilometre.

The landline develops a fault and an ohm-meter is used to locate the fault so that the landline can be dug up at this point and repaired. For the purpose of the test the landline is disconnected from its circuit at both ends.

The readings that are obtained are shown in this table:

Ohm-meter connections	Resistance measured Ω
Start of white conductor, and start of black conductor.	infinite
Start of white conductor, and earth.	110
Start of black conductor, and earth.	infinite
End of white conductor, and earth.	90

(a) Explain carefully the likely nature of the fault.

....

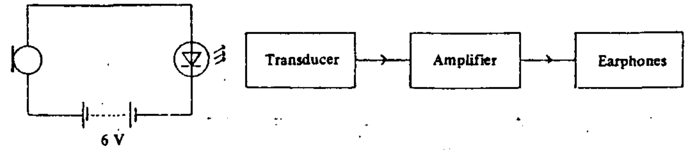
.... *2 marks*

(b) How can the resistance measured be 110 Ω if each whole conductor has a resistance of 100 Ω ?

.... *1 mark*

(c) Calculate the distance, from the start of the landline, where the fault is to be found:

The fault is .... kilometres from the start. *4 marks*



The system is described as working in this way. In the transmitter the current through the light emitting diode is modulated by means of a microphone. The amount of light radiation produced is proportional to the current flowing through the diode. Thus the light output is modulated with the speech signal and this is focussed onto the transducer of the receiver. The resulting audio signal is amplified and fed into the earphone.

(a) Give an example of when such a system could be rather more useful than a simple telephone system.

.... *1 mark*

(b) Give two advantages of such a system as this.

....

.... *2 marks*

(c) Explain how a change in the sound level in the microphone results in a change in the output of light from the LED.

....

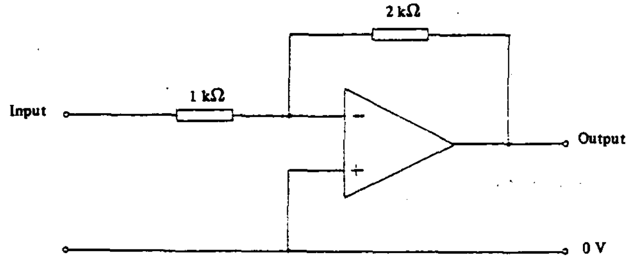
.... *2 marks*

(d) By means of a labelled diagram illustrate what is meant by *amplitude modulation.*

4 marks

11. The amplifier in these circuits uses a ± 12 V power supply, which is not shown in the diagrams.

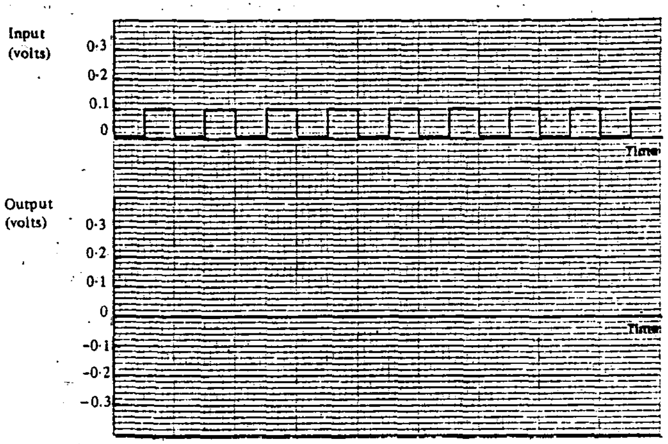
(a)



(i) Calculate the gain of this circuit.

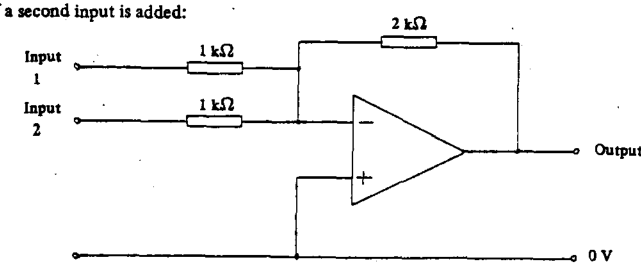
Gain = ...

(ii) If the input is the square wave shown below sketch the corresponding output:

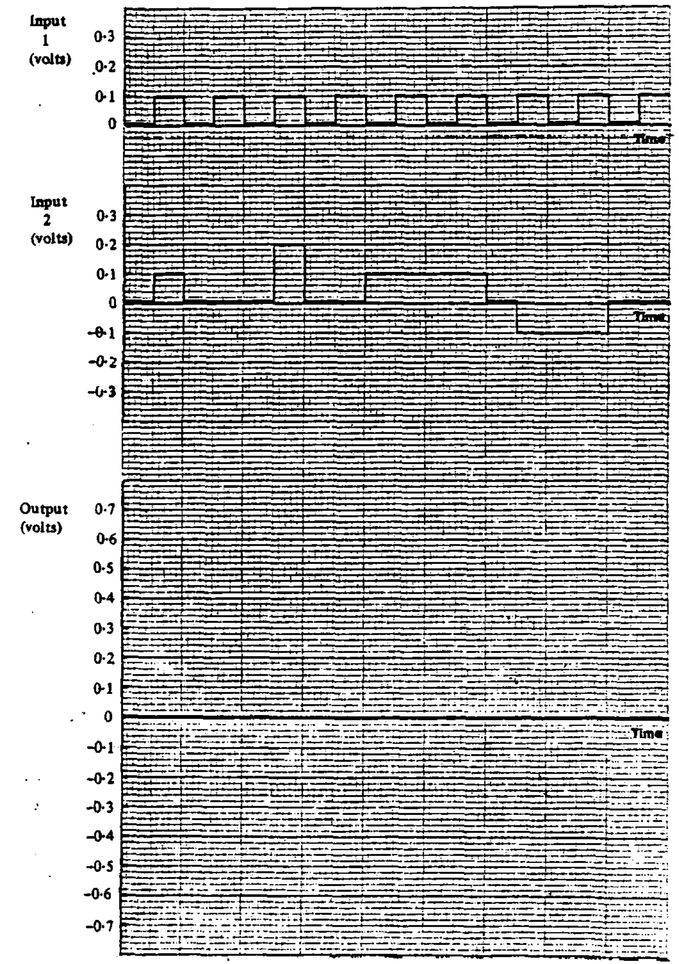


5 marks

(b) If a second input is added:



sketch the corresponding output when the two inputs shown below are applied at the same time.



4 marks

THE ASSOCIATED EXAMINING BOARD
for the General Certificate of Education

June Examination, 1983 – Ordinary Level

ELECTRONICS

Paper 2 **080/2**

Wednesday, 22 June, 9.30 a.m. to 11.30 a.m.

2 hours allowed

You should attempt **FOUR** *questions altogether including:*

ONE *question from Section A*
ONE *question from Section B*
ONE *question from Section C*
ONE *further question from*
either *Section B* **or** *Section C*

Simple clear diagrams should be used when they will help in answering a question.

In calculations all working should be shown.

This paper carries 40% of the total marks for the examination.

Data: The scale of preferred values is:

1.0	1.2	1.5	1.8	2.2
2.7	3.3	3.9	4.7	5.6
6.8	8.2			

The colours in the resistor colour code correspond to the following values:

Black:	0	Green:	5
Brown:	1	Blue:	6
Red:	2	Violet:	7
Orange:	3	Grey:	8
Yellow:	4	White:	9

SECTION A

Answer **ONE** question only from this Section.

1. In the next few years much of the equipment in the home will be controlled by microprocessors.

   (a) State three examples of domestic equipment (other than microcomputers) which can now be *controlled* by microprocessors instead of by switches and wired logic units. *3 marks*

   (b) Draw a block diagram of a typical microprocessor system. Use this diagram to show how the microprocessor is used in ONE of your three examples by indicating what information it must take account of and the parts of the machine that it has to control. *9 marks*

   (c) With reference to your chosen example explain some of the advantages and disadvantages that a built-in microprocessor may produce. *8 marks*

2. A large insurance company has out-of-date telephone facilities. There are two systems, one for internal calls and the other for outside calls. All outside calls pass through a manually operated switchboard where the operator has to get the number required and then plug the caller into this line. Only certain senior staff have lines connected to this switchboard.

   (a) What features of the existing system could be improved by the installation of modern equipment? Draw a block diagram to show the basic arrangement of such an improved system. *8 marks*

   (b) What *additional* facilities would be available with the installation of an improved system? *6 marks*

   (c) Briefly discuss the advantages and the disadvantages of modern equipment for the telephone system of an insurance company. *6 marks*

3. Army units in action have problems with communications. Visual signalling and the laying of landlines are both used but modern armies rely largely on radio.

   (a) Explain how a radio system is arranged that will enable a static headquarters to communicate with several nearby mobile units. Illustrate your answer with a block diagram of the system and state the essential characteristics of the equipment used. *8 marks*

   (b) Explain what other equipment would be required and how it could be used to extend the same type of radio communication over a much larger distance. *4 marks*

   (c) Explain some of the advantages of using radio to communicate in this way. *4 marks*

   (d) Explain some of the disadvantages of using radio to communicate in this way. *4 marks*

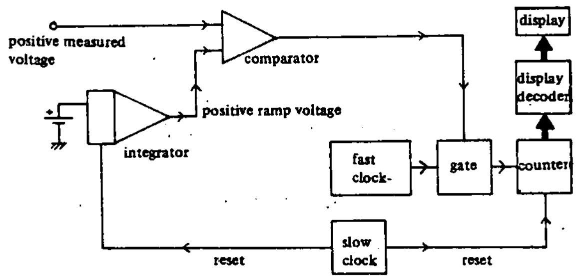
TURN OVER FOR NEXT QUESTION

20

SECTION B

Answer at least ONE question from this Section, but not more than TWO.

4. The figure below shows the block diagram of a digital voltmeter.



A pulse from the slow clock causes both the integrator and counter to reset to zero and then to start again.

(a) Sketch a voltage – time graph of the output from the integrator. *3 marks*

(b). Explain what the counter is doing as the voltage from the integrator is changing. *2 marks*

(c) Explain the sequence of events that stops the counter. *3 marks*

(d) Explain how this arrangement measures the voltage applied to the comparator. *4 marks*

(e) What would be the effect on the reading if the next pulse from the slow clock came too soon? *2 marks*

(f) Explain three of the important differences between this type of digital voltmeter and an analogue voltmeter. *6 marks*

5. Most multimeters can measure three quantities: voltage, current and resistance.

(a) Describe how you would use a multimeter to test for each of the following faults. In each case state which of the quantities you would switch the multimeter to measure, how you would connect the multimeter and the reading you would expect to obtain.

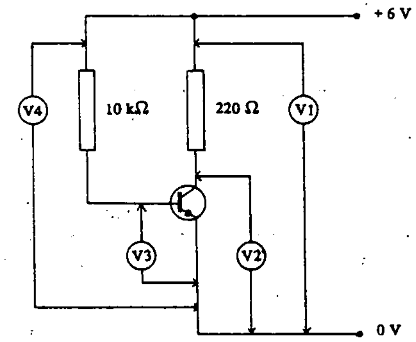
(i) A "blown" fuse.

(ii) A milliammeter which is apparently giving an incorrect reading.

(iii) A short circuit capacitor.

(iv) A "burnt-out" diode. *8 marks*

(b) In the circuit below the silicon transistor is normally biased into the active region with the resistor values shown. When the circuit develops a fault a multimeter is used to test the circuit. It is used in the voltage position and four voltages are read.



(i) If the four readings are:

V1 = 6 V
V2 = 6 V
V3 = 0 V
V4 = 6 V

Explain why these readings indicate that there is a fault. Explain where the fault is most likely to be.

(ii) If the four readings are:

V1 = 6 V
V2 = 0 V
V3 = 0 V
V4 = 6 V

and there is no change in any of these readings on removing the 10 kΩ resistor, explain why these readings indicate that there is a fault. Explain where the fault is most likely to be. *7 marks*

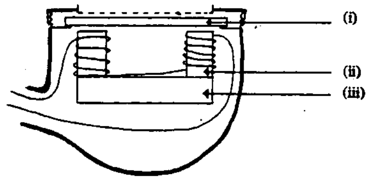
(c) Suppose that the transistor was found to be working satisfactorily and you know that:

$$h_{FE} = 40.$$

Calculate the currents you would expect to find flowing through each of the two resistors. *5 marks*

6. Answer ONE of the alternatives below relating to diagrams of equipment that you may be familiar with.

ALTERNATIVE 1
This is a diagram showing the construction of the earpiece of a telephone.



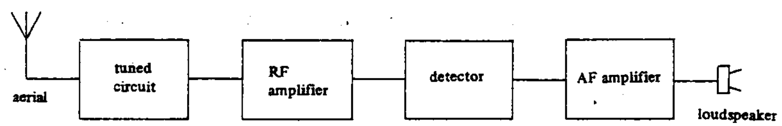
(a) State what each of the three parts labelled (i), (ii) and (iii) is made of. *3 marks*

(b) Explain how varying current through the coils is able to produce sound waves. *5 marks*

(c) In order to connect a caller to the person he requires to contact a series of pulses are produced in the caller's telephone. Draw a diagram of the part of the telephone which produces these pulses and explain how it works. *8 marks*

(d) Explain briefly how these pulses are able to route the call being made. *4 marks*

OR ALTERNATIVE 2
A block diagram of a tuned radio frequency (TRF) receiver is shown below.



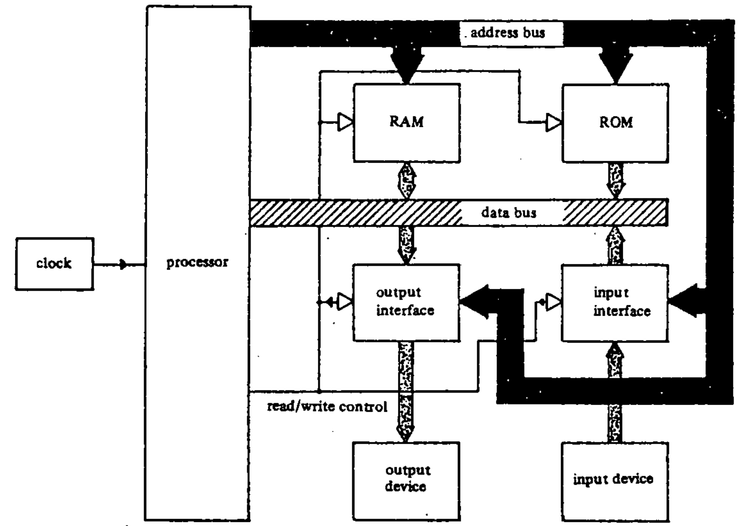
(e) Explain what happens to the radio signal at each of these stages. *6 marks*

(f) Draw a block diagram of a superhet receiver. *5 marks*

(g) Explain how a superhet receiver works. *5 marks*

(h) Explain the advantages of a superhet receiver over the simpler TRF receiver described above. *4 marks*

OR ALTERNATIVE 3
This diagram shows, in simplified form, the structure of a typical microcomputer.



(j) Name three types of devices that would be suitable as input devices. *3 marks*

(k) Name three types of devices that would be suitable as output devices. *3 marks*

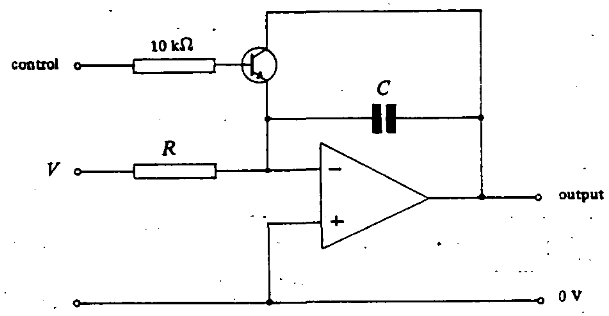
(l) Briefly explain the functions of the clock and the processor in operating the computer. *4 marks*

(m) Explain the differences between the two memories, RAM and ROM, and why the data bus to the RAM has arrows in two directions but that to the ROM has a single arrow. *4 marks*

(n) Suppose that there are eight lines in the address bus. Describe the kind of signal that will be sent along this bus and how the processor is able to direct its data to one particular address in one of its memories. *4 marks*

(p) With eight lines in the address bus how many possible addresses can be selected? *2 marks*

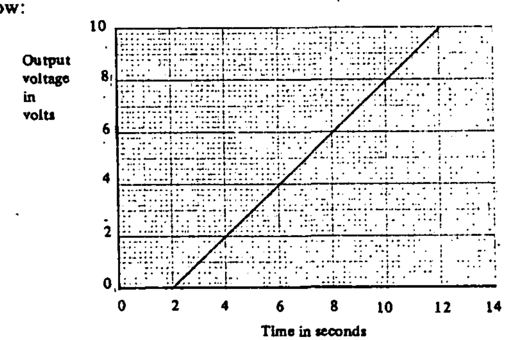
7. This diagram shows the circuit of a ramp generator (power supply ± 10 V not shown).



The output will produce a ramp voltage when the control voltage drops from a positive voltage to zero.
The rate of rise of the ramp voltage is calculated by the formula:

$$\textit{Ramp rate} = -\frac{V}{RC}$$

(a) The required output from this circuit is the voltage ramp shown in the graph below:



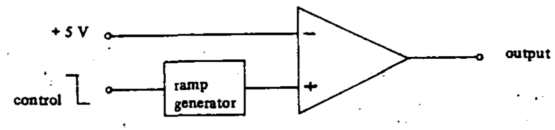
(i) Calculate the ramp rate shown on this graph.

(ii) Using the formula above calculate the value of C, the size of the capacitor, if

$$V = -10 \text{ V}$$
$$R = 1 \text{ M}\Omega$$

(iii) Using the same scales draw a graph of the control voltage required to produce this ramp voltage. *5 marks*

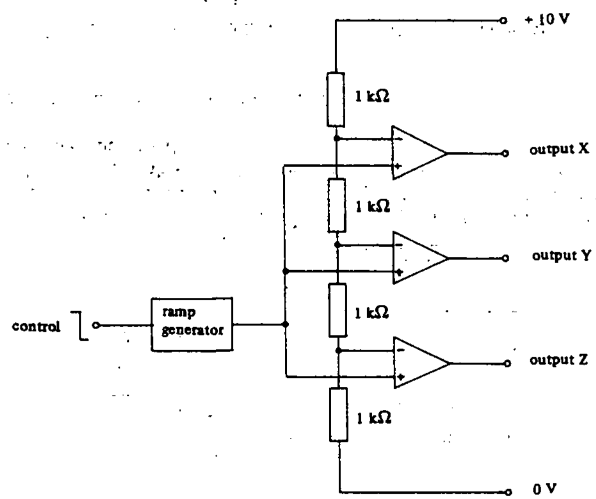
input of the operational amplifier below (power supply ± 10 V not shown) and + 5 V is applied to the inverting input.



(i) Describe and explain what happens to the output of the op-amp after the control voltage received by the ramp generator goes to zero.

(ii) State **two** ways of increasing the delay between the control voltage going to zero and the change in the op-amp output taking place. *6 marks*

(c) The ramp generator is connected to several op-amps in the following way:



Explain how the changes in the outputs from X, Y and Z differ after the control voltage goes to zero. *3 marks*

(d) An advertising display consists of mains powered lighting arranged in three sections. The sections come on in sequence, section 1 first, sections 1 and 2 two seconds later and then all three sections five seconds later again. If this display is controlled by the circuit shown in (c), with the resistor values changed,

(i) calculate suitable values for the resistor chain

(ii) draw a circuit diagram that would be suitable for connecting output Z to its section of the display. *6 marks*

[Turn over

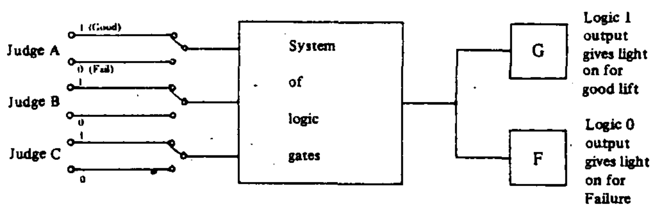
8. (a) Write out the truth tables for the following logic gates:

(i) a single input NOT gate,

(ii) a two input AND gate,

(iii) a two input NAND gate. *3 marks*

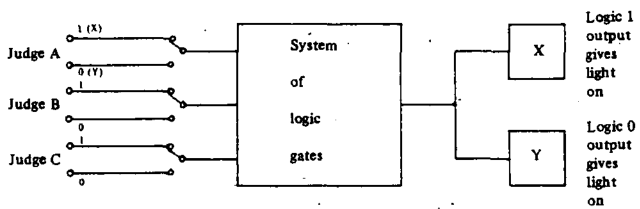
(b) In many sports judges often have to say whether or not something has been correctly done. In weightlifting all three judges have to say that a lift was satisfactory before that lift is allowed. A machine to do this would be in the following form:



(i) Write out the truth table for the system of logic gates.

(ii) Draw a block diagram to show an arrangement of NAND gates that would work in this way. *6 marks*

(c) In boxing three judges have to state which boxer is, in their opinion, the winner. The boxer with the majority of votes is the winner. A machine to do this would be in the following form:



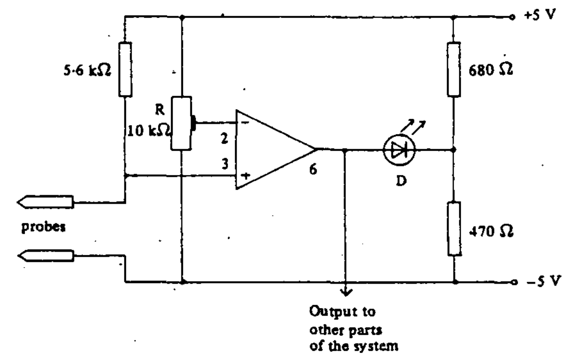
(i) Write out the truth table for this set of logic gates.

(ii) Draw a block diagram to show an arrangement of NAND gates that would work in this way.

(iii) This circuit has the disadvantage that one or other of the lights is on all the time. Suggest a means by which neither display comes on until all three judges have made their decisions. *11 marks*

9. Large potted plants are part of the decoration of many modern offices, but they need to be kept moist, even when the offices are closed. It is proposed to achieve this by means of an electronic control system which will monitor the state of the soil around the roots every twenty minutes and allow a small amount of water to be added if the soil is too dry. A warning light is to be illuminated if the soil is too dry, and a buzzer should sound if no water flows when the supply is turned on, indicating that the reservoir tank is empty.

The following circuit has been suggested for the detector unit which monitors the amount of moisture in the soil. This moisture will determine the resistance between the probes. The operational amplifier in this circuit is connected to a power supply (not shown) of ± 5 V.



(a) With the variable component R set at its mid-point position, D is lit when the probes are pushed into 'dry' soil and not lit when the probes are in 'wet' soil. In dry soil the probe-to-probe resistance is at least 50 kΩ and when in wet soil it is no greater than 1 kΩ.

Briefly explain how the circuit operates. *6 marks*

(b) Calculate, for 'wet' soil conditions and with R set at its mid-point position;

(i) the voltage at pin 2 of the op-amp

(ii) the voltage at the junction of the 470 Ω and 680 Ω resistors

(iii) the voltage at pin 6 of the op-amp. *5 marks*

(c) What is the purpose of making R variable? *1 mark*

(d) Draw a **BLOCK DIAGRAM** to show how the output of the detector unit could be connected to other blocks to allow water to be supplied for about ten seconds and then to allow it to soak in for about twenty minutes before any more water is added. The water supply is controlled by a solenoid valve which operates like a relay, turning on the water when a current flows in the coil.
Briefly explain how your system works. *5 marks*

(e) How would you make a buzzer sound when the supply is turned on and no water flows? *3 marks*

THE ASSOCIATED EXAMINING BOARD

for the General Certificate of Education

ELECTRONICS
Ordinary Level (080)

NOTES FOR THE GUIDANCE OF TEACHERS

This pamphlet has been prepared to assist teachers of Ordinary Level Electronics by providing further information on those aspects of the syllabus and scheme of examination which are relatively new developments in this subject area. It contains the following sections:

1. Philosophical background to the syllabus
2. Syllabus topics
3. Books
4. Apparatus and equipment; typical requirements
5. The nature of project work in Electronics
6. The Project Brief
7. Assistance to candidates carrying out projects
8. Group projects
9. Project reports
10. Project assessment
11. Systems for symbols, diagrams and units

An addendum quotes extracts from the report on the first examination in 1982.

1 THE PHILOSOPHY OF THE EXAMINATION

Developments in Electronics have been taking place in schools and colleges now for many years. This is a reflection of two trends. The first is the increased interest in the curricular contribution of subjects in the area of applied science, technology and engineering science as an effective means for training abilities in selection and decision making, judgement and evaluation; the second trend is the rapid increase in the importance of electronics in all parts of everyday life. This subject is intended to provide for teachers a medium through which the educational objectives implied in these two trends may be achieved.

The Board offers two other syllabuses in the field of Electronics, each with its own level and approach. In addition to this O-Level syllabus, Electronic Systems is an A-Level subject and Electronics can be taken as an A-Level endorsement, endorsing pass grades in Physics, Engineering Science, Electronic Systems, Computer Science and Physical Science. Electronics Endorsement is biassed towards physical electronics and is therefore complementary to A-Level Electronic Systems. Details of both these syllabuses are given in the current syllabus book.

This O-Level course is biassed towards systems electronics, in which the emphasis is on the overall characteristics and interactions of devices and functional blocks rather than physical electronics in which the performance of devices is interpreted in terms of the behaviour of constituent materials. A full 'systems' approach is not envisaged, since that is more appropriate to Advanced Level. However, there are are aspects of the systems approach which are relevant at Ordinary Level, particularly:

(a) that a system can be synthesised from a number of 'building blocks'

(b) that these 'building blocks' can be implemented from basic components

(c) that electronic systems are concerned with the representation and processing of information.

Ordinary Level Electronics is intended to be complementary to Physics and the systems bias will enhance its value as a complementary study. There is inevitably a small proportion of the subject matter which is common to both syllabuses, but even within the overlapping areas there will be a tendency towards a different approach since in Electronics the subject matter will often be applied to aspects of a range of systems.

A project is included in the scheme. It is in fact structured and assessed as an exercise in problem solving designed to develop higher abilities of analysis, synthesis and evaluation. Study of the assessment scheme, together with the additional notes in Section 10 of these Notes for Guidance, will serve to indicate the specific criteria being assessed. It should be noted that the project is intended to develop a range of skills. Teachers will be able to adapt projects to the equipment and expertise available and the particular interests of their students. It is intended that teachers should exploit the enormous resource of student motivation to achieve high standards in the skills sought.

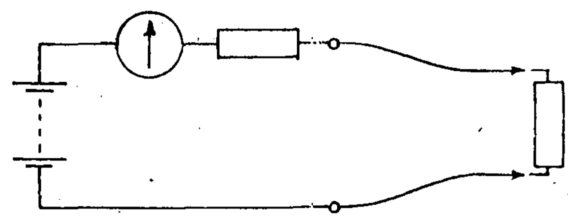
Inevitably, in a new subject area, particularly one in which the "state of the art" is changing rapidly, teachers will find aspects of the subject for which they feel limited in their own knowledge. These notes are intended to provide a starting point for development of the necessary expertise, in addition to providing guidance on specific points of content or administration.

2 SYLLABUS TOPICS

The purpose of these notes is to explain more fully those parts of the syllabus that may cause difficulty for teachers, because the material may be new to them. The treatment here of these sections is necessarily brief. For a full discussion of these points teachers are referred to the book list in Section 3.

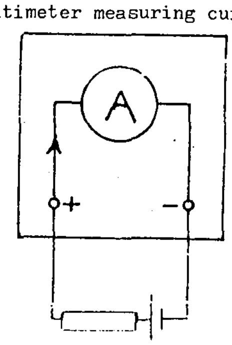
2.1 CIRCUIT OF A SIMPLE OHM-METER (Syllabus Section 1)

Candidates are expected to be familiar with the the following circuit for a resistance meter:

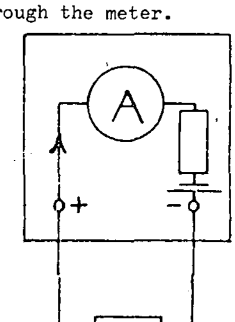


In many multimeters the resistance range is implemented using this circuit. Moreover, the meter connections are usually not switched so that the resistance under test sees a positive voltage appearing at the negative terminal of the meter. This is illustrated below:

(a) multimeter measuring current



(b) multimeter measuring resistance. Current flows in the same direction through the meter.



When testing the polarity of semiconductor devices, it is important to check which terminal appears positive to the device.

It is also important to realise that the voltage across a very high resistance will be the voltage of the internal battery. Hence the voltage across a reverse-biassed diode-junction will be the battery voltage. On high resistance ranges multimeters generally use a higher voltage battery than on lower ranges (the AVO 8 uses 15 V for its highest range and 1.5 V for the lower ranges). Although most diodes will withstand this higher reverse voltage, p-n junctions of transistors will not. With modern silicon transistors, the base-emitter junction usually has a reverse-breakdown voltage of 5 V. Exceeding the reverse-breakdown voltage is the most reliable way to destroy a transistor!

2.2 DIGITAL MEASUREMENT (Syllabus Section 1)

Nowadays digital multimeters are almost as cheap as analogue instruments. Although many schools will not yet be using digital multimeters, they are sufficiently important to warrant inclusion in the syllabus. A digital voltmeter is also a good example of a system that can be built from the building blocks in section 4 of the syllabus.

At the time of writing these notes, the most popular method of analogue to digital conversion in multimeters is the dual-slope-ramp principle. This is too complicated for ordinary level candidates. The method required for this syllabus is the simpler single-slope method. A block diagram of the A-D converter is reproduced underneath. Its operation is explained as follows and candidates will be expected to give an explanation along these lines:

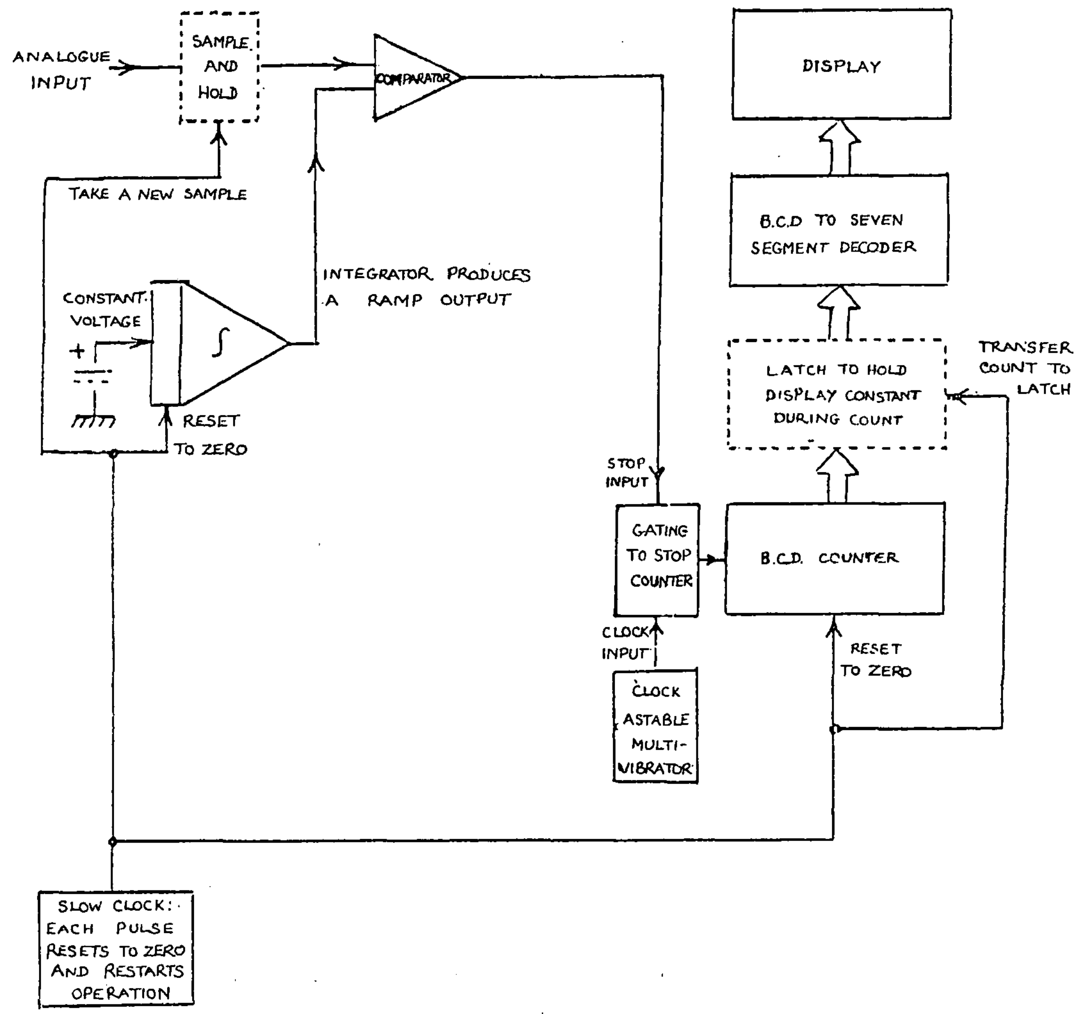
(i) The counter is set to zero; the integrator output is reset to zero.

(ii) The stream of clock pulses from the astable multivibrator (in reality a crystal-controlled oscillator) is fed to a counter.

(iii) The integrator produces a ramp-voltage output (i.e. the voltage is proportional to time).

(iv) The ramp-voltage is compared with the analogue input. When they are equal the counter is stopped.

(v) The time taken for the ramp-voltage to equal the input is proportional to the number reached by the counter; this number is therefore proportional to the input voltage. Scaling is arranged so that the number gives a direct reading in volts.

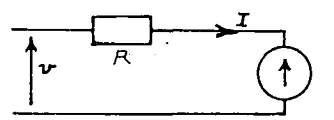
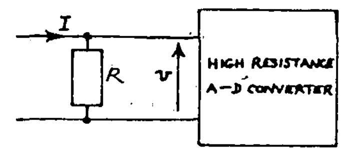
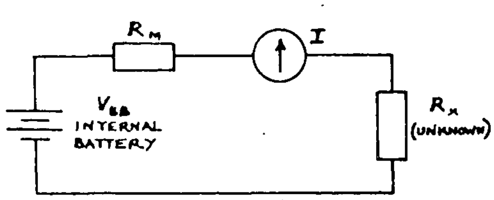
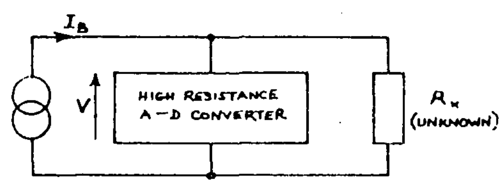


Note: The two blocks in dotted lines can be omitted and need not be taught for this syllabus:

(a) if the analogue signal is charging slowly or is just a d.c. quantity the sample and hold block is not necessary and the analogue input is compared directly with the ramp

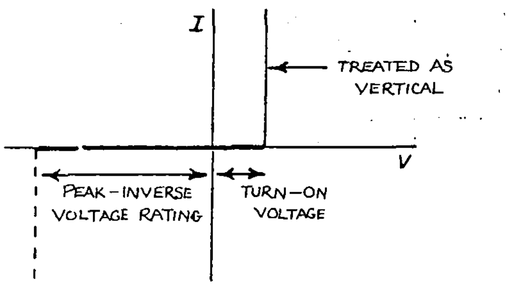
(b) the latch holds the display constant with the last value while the counter is counting.

There are a number of differences between digital multimeters and analogue multimeters, both in principle and in use. These differences are listed below.

	ANALOGUE	DIGITAL
(a)	**Principle**	
(i)	basic measuring device (moving coil meter) is a low-resistance current-measuring device.	basic measuring device (A-D converter and display) is a high-resistance, voltage-measuring device.
(ii)	basic range is low current; higher current ranges use shunts across the meter	basic range is low voltage; higher ranges use potential-dividers before the input to the A-D converter
(iii)	voltage is measured using the circuit below:  series resistor makes the current through the meter proportional to the input voltage	current is measured using the circuit below:  parallel resistor makes the voltage at the input to the converter proportional to input current
(iv)	resistance measured using the traditional ohm-meter circuit  $I = V_{BB}/(R_M + R_X)$ Non-linear scale for resistance	resistance measured by passing a constant current through unknown resistance and measuring the voltage across it  $V = I_B R_X$ (scale is linear)
(v)	meter responds continually (within its frequency range)	analogue input is sampled
(b)	**In Use**	
(i)	output is a continuous function of time	input is sampled
(ii)	however accurate the meter, the resolution is limited to the accuracy with which the pointer can be read	the resolution is limited by the accuracy of the instrument; as many digits as necessary can be added to the display
(iii)	the scale is continuous	the smallest change is 1 digit i.e. the display is discrete
(iv)	analogue and digital displays both have their protagonists	analogue and digital displays both have their protagonists
(v)	(non-electronic analogue meter) consumes no power (but does need an internal battery for resistance range)	consumes power. With liquid-crystal display the power consumption is very low and battery operation is feasible.
(vi)	(non-electronic analogue meter) moderate input resistance on voltage ranges - generally 20 V_R kΩ/V where V_R is the full scale voltage on that range. Resistance is different on each range.	high input resistance on voltage ranges, usually 10 MΩ . Resistance same on all ranges.
(vii)	the only disturbance to the circuit under test is due to the resistance of the meter.	despite manufacturers' claims, switching in the meter usually introduces noise spikes into the circuit under test.

2.3 DIODES

At this level the characteristic curve given to students should be idealised as illustrated below.



Typical values for the turn-on voltage should be known. For silicon diodes this is 0.7 volt (approximately) for germanium diodes 0.2 volt (approximately).

In selecting a diode the average load current and the peak-inverse-voltage rating are the basic parameters. The peak-inverse-voltage for a diode in a half-wave rectification circuit with a smoothing capacitor (or secondary cell on charge) connected to an a.c. supply with r.m.s. rating, $V_{r.m.s.}$ is $2\sqrt{2}\ V_{r.m.s.}$ For a bridge circuit it is $\sqrt{2}\ V_{r.m.s.}$ (providing the diodes are accurately matched).

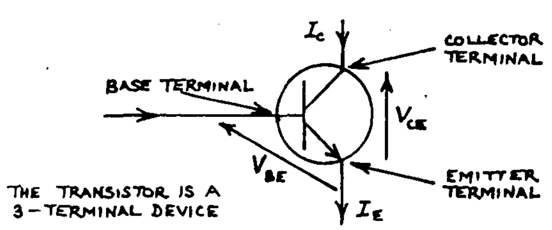
The output voltage of a half-wave rectifier circuit connected to a load and with adequate smoothing will be $\sqrt{2}\ V_{r.m.s.} - 0.7$ volts d.c. approximately if the diodes are silicon. For a full-wave bridge circuit the output voltage would be $\sqrt{2}\ V_{r.m.s.} - 2 \times 0.7$ volt d.c.

Where diodes are employed in logic circuits the value of turn-on voltage is particularly significant - see Section 2.7.

2.4 BIPOLAR JUNCTION TRANSISTOR
(Syllabus Section 2)

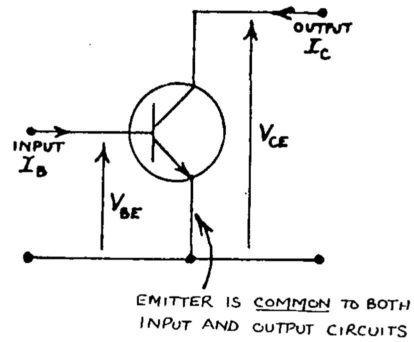
No treatment of the physics of the transistor, nor of small-signal equivalent circuits, is required.

Only n-p-n transistors are to be covered; the following simplified approach should give sufficient guidance for teachers; details are given later of the specific parts that candidates need to know.



The most common circuit configuration is the common-emitter configuration and this syllabus implicitly restricts treatment to this configuration.

Notice the polarities of the voltages and currents for the n-p-n transistor.



In this configuration the base terminal is the input and the collector terminal the output. A full description of the relationships between

$$I_B,\ V_{BE},\ I_C \text{ and } V_{CE}$$

is given by the transistor characteristics which are a set of graphs.

However, engineers prefer design techniques using parameters to design techniques using graphs. Parameters vary considerably between transistors, even between transistors of the same type, and it is much easier to consider worst-case conditions with parameters. No treatment of worst-case conditions is required for this syllabus.

A simplified explanation of the way in which the common-emitter transistor operates is as follows:-

(i) if V_{BE} is less than a certain value (usually taken as 0.7 V) $I_C = 0$ and the transistor is said to be OFF.

(ii) Once V_{BE} reaches 0.7 V, I_C can flow. To get a flow of collector current, base current must be supplied. The maximum value of collector current (it may be less because it may be limited by the external circuit) that can flow is given by

$$I_C = h_{FE}\ I_B$$

h_{FE} is a parameter of the transistor and is considered in more detail later. The base current must be limited by a resistor - again this is covered later.

(iii) V_{CE} does not directly depend on the input circuit. I_C is a direct function of the input and V_{CE} is a function of I_C and the external circuit.

(iv) Over a limited range h_{FE} is approximately constant for a given transistor although it varies between transistors, even between transistors of the same type.

h_{FE} is defined as I_C/I_B. If you see an equation of the form

$$I_C = h_{FE}\, I_B + I_{CEO}$$

(I_{CEO} being a leakage current) this is incorrect; the transistor parameter in this equation should be h_{FEL}.

The correct equation should be

$$I_C = h_{FEL}\, I_B + (1 + h_{FEL})\, I_{CBO}.$$

h_{FE} is not the same as h_{fe}. h_{fe} is a parameter used when considering the small-signal performance of a transistor. h_{fe} is defined as $\partial I_C / \partial I_B$.

Usually h_{FE}, h_{FEL} and h_{fe} have a closely similar numerical value but they do represent very different things. It is worthwhile to be pedantic as incorrect use can, and usually will, cause confusion.

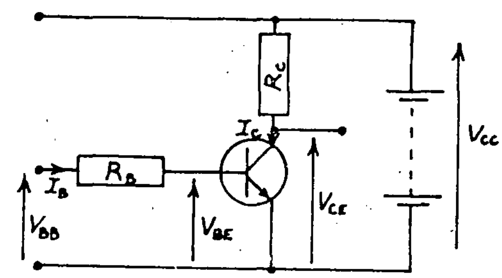
In this syllabus only h_{FE} is required. Typically it has a value of 100 or more.

More confusion is caused by using β. β comes from the physics of the transistor; confusion results because β is used to mean h_{FE}, or h_{FEL} or h_{fe}. Also, engineers use β as the feedback factor in transistor circuits! Moral: avoid β.

However, candidates who write h_{fe} or β instead of h_{FE} will not be penalised in the examination.

Transistors are not used in isolation. The most common use of the transistor is as an amplifier or as a switch; this syllabus only requires the transistor as a switch.

The circuit below shows the standard common-emitter switching circuit.



Kirchhoff's voltage law can be applied to both the base-emitter mesh and the collector-emitter mesh to give:

$$V_{BB} = I_B R_B + V_{BE} \quad \text{or} \quad I_B = (V_{BB} - V_{BE})/R_B$$

$$V_{CC} = I_C R_C + V_{CE} \quad \text{or} \quad V_{CE} = V_{CC} - I_C R_C$$

(a) $V_{BB} = 0$. The transistor is OFF. $I_C = 0$ and $V_{CE} = V_{CC}$

(b) $V_{BB} > 0.7$ V. V_{BE} rises to 0.7 V and I_B is given by $(V_{BB} - 0.7\text{ V})/R_B$. Notice that R_B must be included to limit the base current because the base-emitter junction is a diode junction. V_{BE} therefore cannot rise much above 0.7 V and if R_B is not included, excessive base current will flow and the transistor will be destroyed.

When the transistor is ON, two conditions must be considered:

(i) when the transistor is not saturated
(ii) when the transistor is saturated

(i) the base current is $I_B = (V_{BB} - V_{BE})/R_B$
I_C is given by $h_{FE} I_B$
V_{CE} is $V_{CC} - I_C R_C$

(ii) It is impossible for V_{CE} to fall below a certain minimum value called $V_{(SAT)}$ (taken as zero in this syllabus)

i.e. the maximum possible value for I_C is V_{CC}/R_C.

If more base current than $V_{CC}/h_{FE}R_C$ is supplied, the excess base current cannot produce more collector current, but does produce extra stored charge in the base region which slows down the response of the transistor.

Candidates are expected to be able to:

(i) decide whether a transistor is ON or OFF in a particular circuit i.e. whether it acts as a closed or open switch

(ii) calculate I_B given an external circuit connected to the base of the transistor

(iii) calculate I_C from the relation $I_C = h_{FE} I_B$ if the transistor is not saturated

(iv) calculate I_C from the external circuit if the transistor is saturated

(v) decide whether a transistor is saturated or not

(vi) calculate V_{CE} from I_C and the external circuit

Candidates are NOT expected to be able to:

(i) know anything about amplification of a.c. signals

(ii) use the terms *gain* or *amplification* in relation to transistor circuits.

.5 USE OF MULTIMETER TO IDENTIFY FAULTY COMPONENTS IN SIMPLE CIRCUITS (Syllabus Section 3)

'he ability to identify which component in a simple ircuit may be faulty calls for the use of eductive skill. It is an advantage of a syllabus f this nature that deductive ability can be ncouraged. This ability is, of course, vitally mportant in practice when trying to get lectronic circuits to work.

iven a set of information (voltage, current or esistance readings) taken from a multimeter, andidates are expected to be able to deduce the ollowing faults:

resistors outside tolerance, open circuit or short circuit

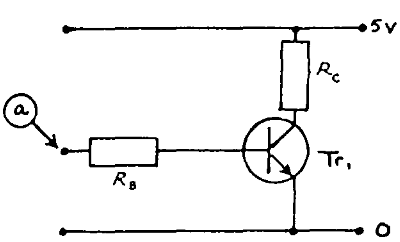
capacitors being short circuit

diode and transistor junctions not having a low forward and a high reverse resistance

dry joints (open circuit connection)

ı example is probably the best way to give ıidance as to the level of complexity to be ınsidered.

(a) (Using voltage measurements)



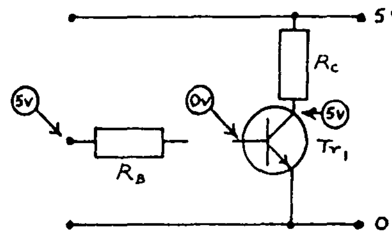
A transistor switch fails to operate. Given the voltage readings tabulated below, identify the fault.

Collector of TR1 : 5 V, Base of TR1 : 0 V. Point (a) of R_B : 5 V.

(i) The base-emitter junction of the transistor could be short circuit.

(This is the answer that is the most obvious and would be expected).

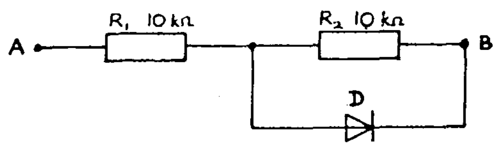
(ii) There could be a dry joint at the junction of R_B and the base of TR1 or R_B could be an open circuit.



(Notice that the voltage was specified at the base of the transistor. Neglecting leakage currents the base voltage would be 0 V under these conditions).

This fault is more obscure and generally would not be expected without further hints in the question.

An example where there could be more than one fault, and where there is a strong hint to this effect in the question is given below:



'An ohm-meter was used to test for a fault in the above section of a circuit. Connection of the meter to A and B indicated a resistance of 10 kΩ whichever way round the meter was connected. There is known to be only one single fault. Which of the components <u>could</u> be faulty and which component or components (if any) can be assumed <u>not</u> to be faulty? Justify your answers.'

There is a strong hint that there is more than one possible fault condition, although for each fault there is only one faulty component.

The two possibilities are:

(i) Diode D short circuit.

(ii) Resistor R_2 short circuit.

2.6 COMBINATIONAL LOGIC CIRCUITS (Syllabus Section 5)

Candidates are expected to know the truth table of the following gates: AND; OR; NOT; NAND; NOR.

AND, OR and NOT are the basic logic functions.

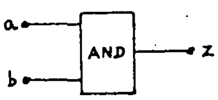
NAND is included because, in practice, combinational logic circuits are most usually implemented with NAND gates.

NOR is included because it is easy to implement with a simple transistor circuit (see Section 6 of these notes).

Although candidates are not expected to know Boolean algebra or De Morgan's theorem they are expected to know that

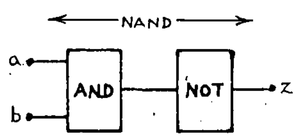
NAND ≡ AND followed by NOT
NAND ≡ NOT of each input, followed by OR.

The first identity is a basic definition of NAND, the second can easily be demonstrated by using truth tables.



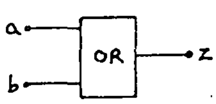
a b	z
0 0	0
0 1	0
1 0	0
1 1	1

AND function



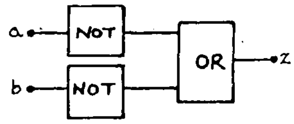
a b	z
0 0	1
0 1	1
1 0	1
1 1	0

NAND function



a b	z
0 0	0
0 1	1
1 0	1
1 1	1

OR function



a b	z
0 0	1
0 1	1
1 0	1
1 1	0

z = (NOT a) OR (NOT b)
This is the same as the NAND function above.

The syllabus requires the identities in this from, a logical approach since AND, OR, NOT are the basic functions and NAND and NOR the derived functions. However, it is probably more useful to write these identities in a different way:

AND = NAND followed by NOT

OR = NOT of each input, followed by NAND.

Boolean algebra is not required. Boolean notation would be useful although candidates writing logic functions in words will not be penalised provided that the expression is clear and unambiguous.

Boolean notation: AND is represented by .
OR is represented by +
NOT is represented by - over the appropriate Boolean variable.

Hence the identity shown previously by truth table can be written as:

$$\overline{a.b} = \bar{a} + \bar{b}$$

NAND = (NOT A) OR (NOT B)

Questions about logic functions are likely to take 3 forms.

(i) questions about the basic logic operations

(ii) questions requiring very simple single gate functions such as the use of an AND gate to enable a signal

(iii) questions requiring some logical function, stated as a problem in words or as a truth table, to be implemented as a circuit of gates.

Questions of type (iii) are the most difficult. Candidates getting the correct answer by any correct method will receive full credit. However, the approach recommended here has advantages in that it does not require Boolean algebra and that it is applicable to any question. It is perhaps best explained with the help of an example.

Problem: A number in the range 0 to 7 is represented as a 3 - bit binary code, bit A representing 2^2, bit B representing 2^1, bit C representing 2^0. Design a logic circuit to give: a logic 1 output when numbers 3 and 4 occur; a logical 0 otherwise.

Step 1: Write down a truth table in terms of the 3 input variables. If these are written in ascending binary code there is less chance of one line being accidentally omitted.

A B C	Z
0 0 0	
0 0 1	
0 1 0	
0 1 1	
1 0 0	
1 0 1	
1 1 0	
1 1 1	

Step 2: Convert the problem in words into a truth table by writing in the left what each line of the truth table represents, and on the right the output corresponding to this condition.

Number	A B C	Z
0	0 0 0	0
1	0 0 1	0
2	0 1 0	0
3	0 1 1	1
4	1 0 0	1
5	1 0 1	0
6	1 1 0	0
7	1 1 1	0

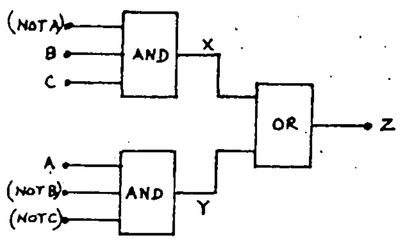
Step 3: Convert this truth table to a logic circuit. This may seem at first to be the most difficult part of the design but in reality it is very easy. The process can be explained step by step by writing logical expressions in words but after some practice the required circuit can be written down by inspection.

(i) From the truth table the output is logical 1: when (a) is 0 AND (B) is 1 AND (C) is 1 OR when (A) is 1 AND (B) is 0 AND (C) is 0

(ii) This is the same as saying that the output is logical 1: when (NOT A) is 1 AND (B) is 1 AND (C) is 1 OR when (A) is 1 AND (NOT B) is 1 AND (NOT C) is 1

Notice that the expressions have been written so that each variable or inverted variable appearing in the expression is '1'.

(iii) The gating required to implement this function is



This is obviously true because Z is 1 when X OR Y is 1.

X is 1 only when (NOT A) AND B AND C is 1
Y is 1 only when (A) AND (NOT B) AND (NOT C) is 1

or using Boolean notation:

$Z = \overline{A}.B.C. + A.\overline{B}.\overline{C}.$

Since no minimisation of the number of gates is required for this syllabus this is the end of the process.

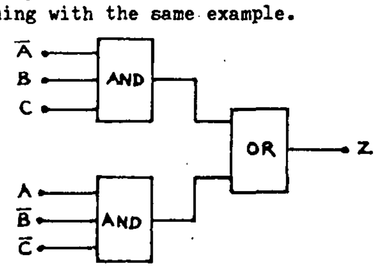
Summarising the rules for getting the final logical expression from the truth table:

(i) the circuit consists of a number of AND gates feeding into an OR gate,

(ii) there is one AND gate for every line in the truth table corresponding to a '1' for the output,

(iii) each AND gate has an input for every input variable. If the variable appears as a '1' in that line of the truth table the variable itself is fed to the input; if the variable appears as '0' its inverse is fed to the input.

The AND - OR circuit derived from the truth table can easily be converted to a NAND - NAND circuit. Continuing with the same example.

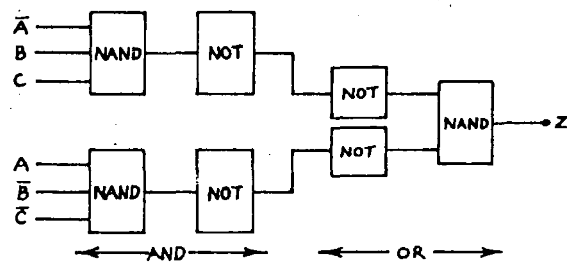


The identities shown earlier were:

AND = NAND followed by NOT

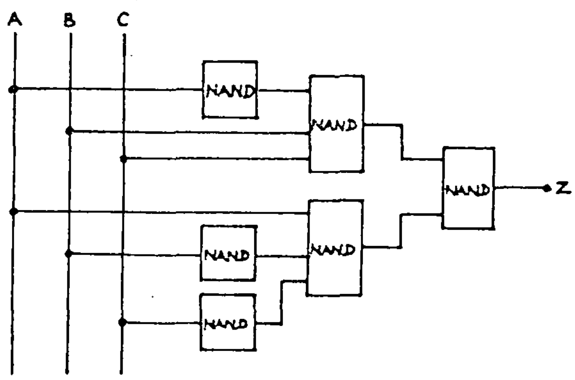
OR = NOT of each input followed by NAND

The circuit becomes:



Double inversion of a variable obviously gives the original variable, i.e. two successive NOT gates cancel each other.

Hence the AND - OR circuit is identical to NAND - NAND. It is also worth noting that a single input NAND gate is an inverter so the complete function can be implemented using NAND gates only.



Section 6C of the syllabus requires the implementation of the full adder as a NAND - NAND function. This is another example that can be solved using the approach described here.

Decimal relationships	Equivalent in binary	u v w	sum S	carry C
0 + 0 + 0 = 0		0 0 0	0	0
0 + 0 + 1 = 1		0 0 1	1	0
0 + 1 + 0 = 1		0 1 0	1	0
0 + 1 + 1 = 2	0 carry 1	0 1 1	0	1
1 + 0 + 0 = 1		1 0 0	1	0
1 + 0 + 1 = 2	0 carry 1	1 0 1	0	1
1 + 1 + 0 = 2	0 carry 1	1 1 0	0	1
1 + 1 + 1 = 3	1 carry 1	1 1 1	1	1

Using the rules explained in this section

$S = \overline{u}.\overline{v}.w + \overline{u}.v.\overline{w} + u.\overline{v}.\overline{w} + u.v.w$

$C = \overline{u}\ v\ w + u\ \overline{v}\ w + u\ v\ \overline{w} + u\ v\ w$

which can be implemented as an AND - OR function or NAND - NAND

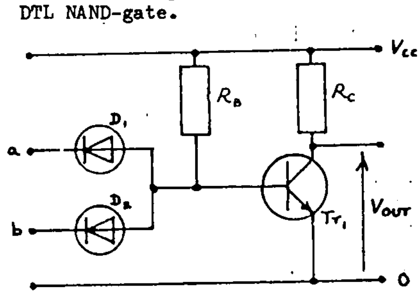
2.7 LOGIC CIRCUITS (Syllabus Section 5)

As stated in the syllabus, this topic is included to provide a link between the treatment of components and the treatment of blocks. It is intended that standard circuits should not be learnt: candidates should be able to deduce the function of a given circuit from details provided.

In most instances questions will be based on DTL NAND-gate or DTL NOR-gate structure.

(a) NAND gate

This is a simplified version of a DTL NAND-gate.

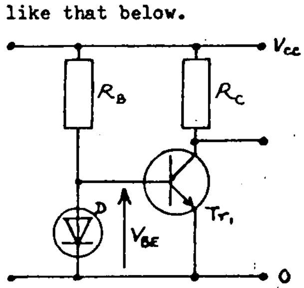


When a positive voltage greater than 0.7 V is applied to both a and b D1 and D2 are reverse-biased and hence each appears to be open circuit. TR1 is turned ON by current flowing through R_B and is saturated provided that $I_B > I_C/h_{FE}$

$I_B \approx (V_{CC} - 0.7\ V)/R_B$

$I_C \approx (V_{CC}/R_C)$

When either a or b is taken to 0V (or if both are) the circuit now looks like that below.



If D is a silicon diode it is impossible to predict what will happen: V_{BE} will be approximately 0.7 V and current will flow through D and through the base-emitter junction. The ratio of these currents will depend upon the exact properties of that particular diode and that particular transistor. Depending upon how much base current flows into the transistor it may still be saturated, or it may be in the ACTIVE region with $I_C = h_{FE}I_B$ being less than V_{CC}/R_C.

However, if D is a germanium diode its forward voltage drop is supposedly 0.2 V: hence the base of TR1 is held at 0.2 V by the diode and the transistor is turned off.

Questions requiring calculations on this NAND circuit will make it clear that germanium diodes are used, unless of course no calculations are required on the circuit in that state.

Summarising the behaviour of this circuit:

a	b	TR1	C	$V_{OUT} = V_{CE} = V_{CC} - I_C R_C$
0 V	0 V	OFF	0	V_{CC} i.e. positive
0 V	pos	OFF	0	V_{CC} i.e. positive
pos	0 V	OFF	0	V_{CC} i.e. positive
pos	pos	ON	should be V_{CC}/R_C	0

if a positive voltage is taken to represent logic 1 the truth table is:

a b	Z (output)
0 0	1
0 1	1
1 0	1
1 1	0

This is clearly a NAND function.

It is interesting to note, *although not part of the syllabus,* that representing logic 1 by 0 V and logic 0 by a positive voltage would give a NOR function with this same circuit.

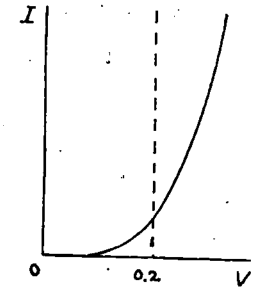
a	b	V_{OUT}
0	0	+ve
OV	+ve	+ve
+ve	0	+ve
+ve	+ve	0

a b	Z
1 1	0
1 0	0
0 1	0
0 0	1

It is therefore, extremely important to be clear about the convention used to represent logic variables by voltages.

Teachers wishing to build a transistor NAND gate should realise that, in practice, the simplified gate considered here may not work, even if germanium diodes are used. There are 2 reasons for this problem:

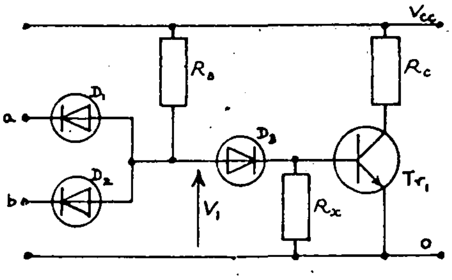
(i) the forward voltage across the diode may well be greater than 0.2 V. Germanium diodes generally have a much higher forward slope resistance than silicon diodes and hence do not have a very sharp turn-on characteristic.



(ii) if the gate is driven by another transistor circuit the 'LOW' input voltage will not be OV but will be between 0.1 V and 0.2 V.

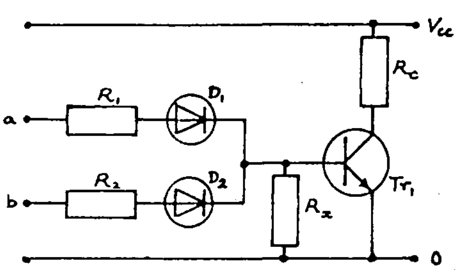
The combination of these two factors may mean that the transistor will not turn off when all the inputs go LOW.

A practical circuit (more complicated than anything forming part of an examination question) is shown below. Silicon diodes can now be used. The inclusion of D3 means that V_1 must reach 1.4 V before TR1 will turn ON, i.e. any input voltage of less than 0.7 V will turn the transistor OFF.



R_x must be included otherwise D3 will prevent the transistor turning OFF properly.

(b) NOR gate.



In practice R_x must be included to enable the transistor to turn OFF. If it were not included diodes D_1 and D_2 would prevent minority carrier charge stored in the base when the transistor is ON from properly flowing out of the transistor when it turns OFF.

This nicety need not be considered for this syllabus and questions on NOR gates will not include R_x.

Without the inclusion of R_x the circuit is straightforward, except that the base current of TR1 depends on the number of inputs that are HIGH. When an input is taken to 0V that diode is reverse-biased.

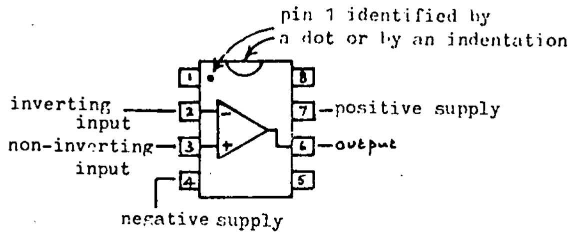
Note that this circuit needs an input of 1.4 V (if silicon diodes are used) before the transistor will turn ON.

2.8 OPERATIONAL AMPLIFIER CIRCUITS (Syllabus Section 5)

Operational amplifiers are very much easier to use than transistors and are now so cheap that they should generally be used in preference to an equivalent transistor circuit, especially when voltage amplification is required.

The most common "op amp" is the 741 which is an industry standard for all general purpose applications.

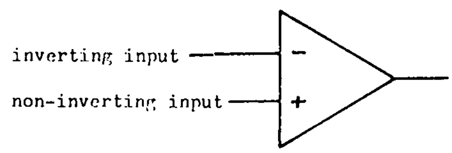
Just because it comes in a package with 8 pins and has 14 transistors inside it does not mean it is more difficult to use than a transistor; indeed it is much easier to use. Of the 8 pins only 5 need be considered for all general purpose applications.



TOP VIEW OF PACKAGE

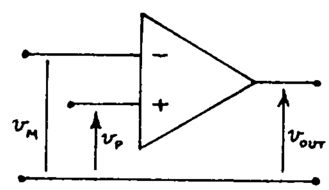
Note that the device needs a dual power supply. Usually a supply in the range ± 9 V to ± 15 V is used. There is no direct connection from the device to the common zero line of the power supply, but input and output circuits are returned to this zero line.

The circuit symbol for an op amp omits the power supply connections as it is understood that they should be there; the symbol is:



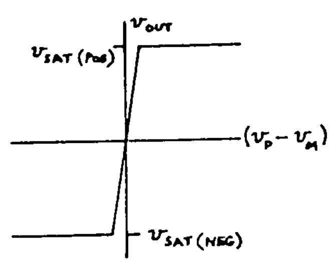
This symbol can be drawn either way up but for the purposes of this syllabus it will always be shown with the inverting input uppermost.

The op amp is a differential amplifier, the output being given by $V_{OUT} = A_V (V_P - V_M)$.



A_V is the voltage gain and is very large, perhaps 10^5. The output voltage cannot be larger than a value just smaller than the supply voltage; this value is called the saturation voltage and because there is a dual supply there are two saturation voltages: $V_{SAT(NEG)}$ and $V_{SAT(POS)}$.

From this it follows that the op amp has a transfer characteristic like that shown below:



The maximum differential input voltage that can be applied without the operational amplifier saturating is therefore V_{SAT}/A_V which is perhaps 150 μV or less. This is the basis for the "intuitive" approach used later for the derivation of the transfer function of op amp circuits.

For most general-purpose circuits it can be assumed that the operational amplifier (usually a 741) behaves as an ideal operational amplifier i.e.

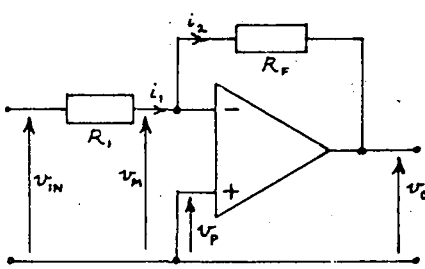
A_V is infinite

each input takes no current

the output has zero source resistance

if the operational amplifier is not saturated $v_p = v_m$

Candidates will not be expected to be able to derive the transfer function of any of the operational amplifier circuits used, in the examination. The derivation of the transfer function for the inverting amplifier is given here (using an intuitive approach) for the benefit of teachers.



Assume that the current flowing into each input is zero. The operational amplifier has negative feedback round it: this acts on the operational amplifier to try to prevent it saturating.

v_M must be almost equal to v_p

If the operational amplifier is ideal the gain is so large that for it not to saturate $v_M = v_P$, $v_P = 0$,

hence $v_M = 0$

$i_1 = (v_{IN} - 0)/R_1$

$i_2 = (0 - v_{OUT})/R_F$

By Kirchhoff $i_1 = i_2$ since the input takes no current.

Hence

$$\frac{v_{IN}}{R_1} = \frac{-v_{OUT}}{R_F} \quad \text{or} \quad v_{OUT} = -\left(\frac{R_F}{R_1}\right) v_{IN}$$

The minus sign is important: a positive input voltage will actually give a negative output.

Another point worth noting is that the gain is dependent only on the two resistors (which can be made with a very small tolerance) and not on the characteristics of that individual operational amplifier (which cannot be made precisely). Naturally the maximum output voltage is still equal to the saturation voltage.

Practical Limitations:
A real operational amplifier does take a finite current at each input, it also has a finite gain and a finite frequency response. These limitations should be completely ignored for this syllabus and are unlikely to present any problems in practice.

2.9 SECTION 6 - GENERAL NOTES

This section comprises a compulsory section and three alternative options allowing teachers to develop an understanding of the role and impact of electronics in society in a context for which they have the necessary information, expertise, interest and equipment.

In the examination, one section of Paper 2 will be based entirely on this section of the syllabus, and certain aspects of this section of the syllabus may also be tested elsewhere in the written papers. Where questions are based on the optional topics three alternatives will be set, one on each topic.

The section of Paper 2 based on Electronics in Society will vary in format from examination to examination. For example it may contain three separate questions, or a single question in which the candidate can draw on his knowledge of whichever option he has studied, or a comprehension passage followed by a series of structured questions. The questions could ask for the application of telephone, radio of computer to particular industries or services (e.g. computing in a bank or radio communication in the armed services) but in this case candidates will be given alternative services/industries on which to base their answers, and the services and industries will be those about which candidates will have some general knowledge.

General notes on the syllabus content have been restricted to a note on radio propagation characteristics (topic II) and details on the Computer Systems topic (topic III). There is a fairly large amount of information available on topics I and II in references quoted in the book list (Section three of these notes).

2.10 RADIO PROPAGATION (Section 6, optional topic II)

Candidates should have a basic knowledge of the following:

(i) Characteristics of radio waves

- (a) they consist of moving fields of electrical and magnetic force
- (b) polarisation
- (c) ionospheric, tropospheric and ground waves

(ii) The ionosphere

- (a) the existence of D, E and F layers
- (b) refraction and reflection
- (c) absorption

(iii) Propagation at LF, MF, HF, VHF, UHF and microwaves

- (a) distances over which communication can be maintained
- (b) uses, and reasons for use, of these frequencies

(iv) The following terms should be understood

- (a) ground waves
- (b) sky waves
- (c) skip distance
- (d) fading

2.11 COMPUTER SYSTEMS (Syllabus Section 6, optional topic III)

The section on computer systems includes material that may well be unfamiliar and these notes give guidance on the level at which it should be taught. It must be stressed again that these notes are necessarily brief and teachers requiring more information are referred to the books listed in Section 3 of these notes.

The inclusion of 'computer systems' as a topic in this syllabus serves two purposes: to show the impact on society of computers (which are a product of electronic engineering) and to show how the microprocessor (the "computer on a chip") can be used as a device in electronic engineering. Since computers are extremely complicated, treatment should be limited to principles.

Basic Computer Operations

(a) Representation of numbers:

Treatment should be limited to integers represented directly in binary code. Candidates should know powers of 2 up to 2^8 and they may be asked to convert decimal numbers in the range 0 to 127 into binary code or from binary into decimal. Candidates may be required to perform numerical operation operations with binary numbers of up to four bits.

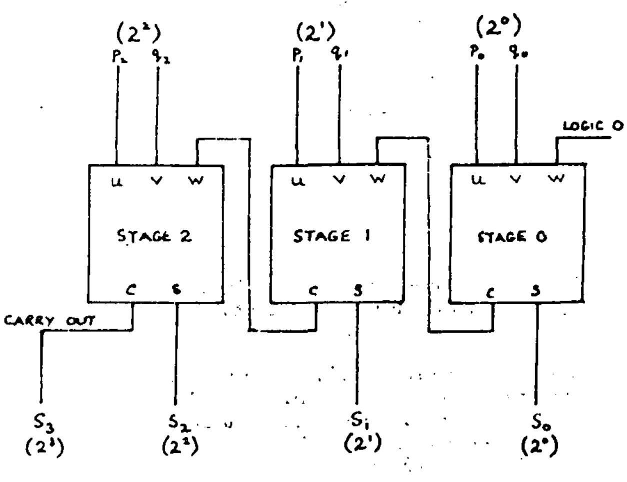
(b) Full Adder:

This has already been dealt with in Section 2.6.

(c) Adding two binary numbers:

The full adder has three inputs:- u, v and w, and two outputs S (sum) and C (carry). Its function is to add together the three binary digits and produce the sum and carry outputs.

It is simpler to draw a block diagram for a parallel adder than it is for a serial adder, and treatment should be restricted to the parallel form. A block diagram for a 3-bit adder is shown below.



The two input numbers are $P_2\ P_1\ P_0$ and $q_2\ q_1\ q_0$: P_0 and q_0 are the least significant bits and P_2 and q_2 the most significant. The carry output from one stage acts as the w input to the next. There is of course no carry in to the addition of the least significant bits but the carry out from the addition of the most significant bits produces the most significant bit of the sum (two n bit numbers added together produce an n + 1 bit sum).

Points: (i) since there is no carry in to stage 0 a half adder can be used instead of a full adder. For this syllabus a full adder in this position is quite acceptable.

(ii) this type of adder is called a "carry-ripple-through" adder because the time taken for the addition is the time taken for the carry out of the first stage to propagate through to the output of the last stage. In modern high-speed electronics a more complicated adder is used (called a "carry look-ahead adder") which predicts the effects of all the carries - no treatment is needed of such complications.

(d) Softwave multiplication:

this is best illustrated by an example.

decimal: 5 x 3 = 15

binary: 101 x 011 = 01111

Write in the form of conventional long-multiplication and perform the usual process, except that addition is binary.

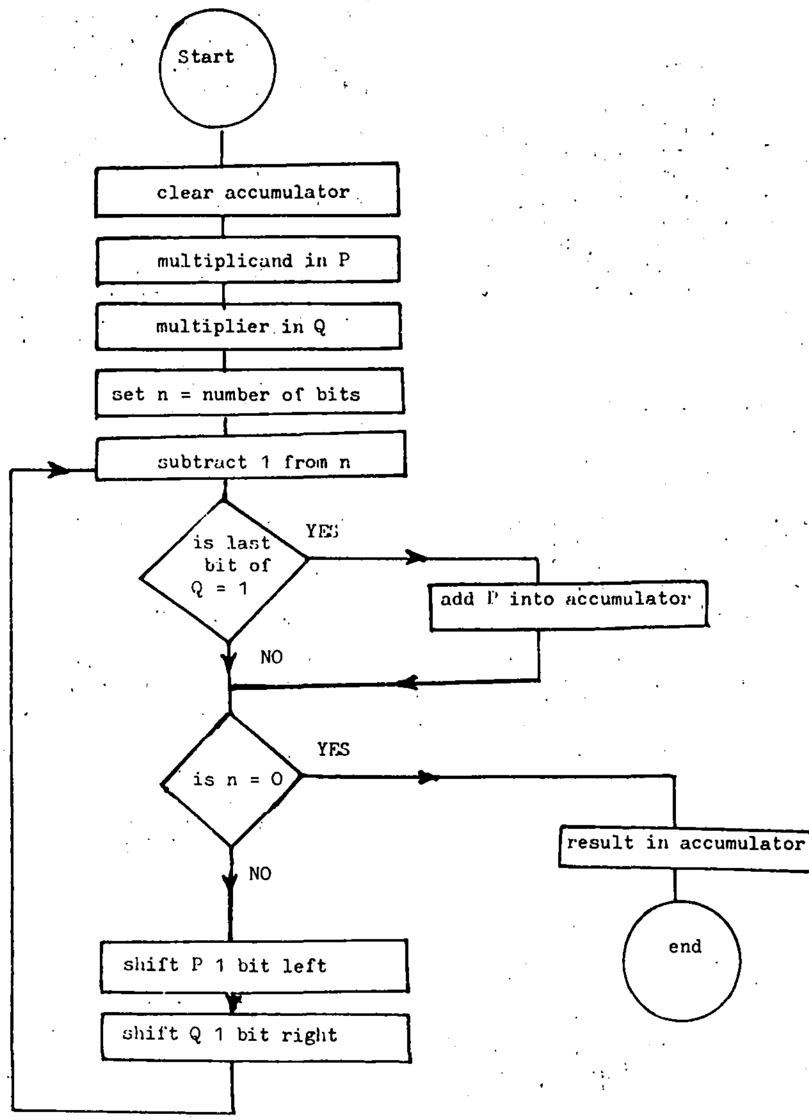
multiplicand:	1 0 1	register P
multiplier:	0 1 1	register Q
	1 0 1	101 x (1×2^0) (LSB of 011)
	1 0 1	101 x (1×2^1) (2nd bit of 011)
	1 1 1 1	add
	0 0 0	1 0 1 x (0×2^2) (MSB of 011)
	0 1 1 1 1	add → 15_{10} in binary

This is equivalent to (in basic computer steps)

Instruction	Result
clear accumulator	acc: 0 0 0 0 0
is last bit of Q 1?	
Yes: add P to accumulator:	acc: 0 0 1 0 1
shift P 1 bit left	P: 0 1 0 1 0
shift Q 1 bit right	Q: 0 0 0 0 1
is last bit Q 1?	
Yes: add P to accumulator:	acc: 0 1 1 1 1
shift P 1 bit left	P: 1 0 1 0 0
shift Q 1 bit right	Q: 0 0 0 0 0
is last bit of Q 1?	
NO: no addition	

the multiplication is now complete: the result is in the accumulator.

This process can be summarised in a flow chart.



Teachers are strongly encouraged to emphasize the close similarity of this process with the standard long multiplication routine of arithmetic computation to the advantage of both this course in Electonics and the student's work in mathematics.

(e) Accumulator and Program Counter

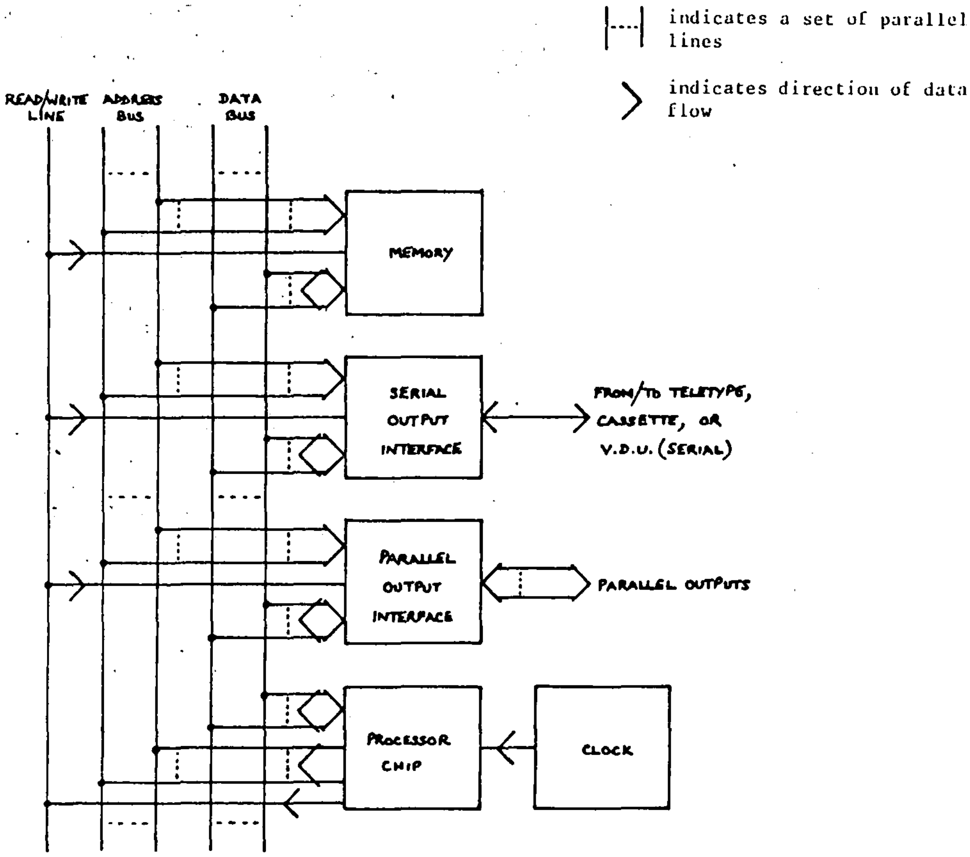
Only a very simple treatment is required of these two registers. Candidates should know that the accumulator is a register into which values stored in memory or other registers can be added.

Candidates should also know that the binary words stored in the memory can represent data or instructions; the program counter holds the address of the next instruction.

Microprocessor Systems

Although some of the jargon may appear frightening the concepts required are fairly straightforward. Bare outlines only are given in these notes and it is expected that teachers choosing the 'computer systems' option would supplement these notes with other reading. It would not be necessary, although it would be desirable, to have a microprocessor in the school when teaching this topic. Microprocessor kits intended for use in school or at home are becoming fairly cheap and within only a few years should be within the budget of most schools. Questions set will require a knowledge of principles, not of the details of any particular microprocessor

(a) Block Diagram



Details of bus operation are given later.

Operation of the microprocessor system can be described very simply:

> the clock governs the frequency of operation of the microprocessor. With a very simple processor one instruction would be executed at each clock pulse.
>
> the processor chip controls the whole processes; it decodes the instructions contained in the programme and performs operations on the data values stored in memory
>
> memory is used to store data and program instructions (see later section)
>
> output-interface integrated circuits enable the microprocessor to communicate with other electronic systems. Of the two types of interface the parallel interface is probably easier to teach as it takes the parallel word put on the data bus by the microprocessor and gives that value to some peripheral (or takes the value from the peripheral and puts it on the bus).

The seven segment LCD or LED displays are parallel interface devices but they are rarely directly interfaced with microprocessor circuits. Thus candidates may be more concerned with serial interfacing, and will have to understand the concept of taking a parallel word and converting it to a serial sequence (and vice versa). Applications for this device are more common: a teletype or VDU is a peripheral requiring a serial interface. Questions on output interfaces will not specify the particular type and candidates may discuss either.

(b) Peripherals: a teletype or alphanumeric VDU (visual display unit) is used to enter data or instructions to the microprocessor and to display output. A brief comparison between the properties of the two types of terminal may be useful.

TELETYPE	VDU
1 mechanical	electronic
2 not particularly reliable (many moving parts)	reliable - electronic components are very reliable
3 slow: data rate is usually 110 baud (110 bits/sec)	can operate very much faster than 110 baud
4 noisy	silent
5 produces a permanent record (in jargon: hard copy)	no permanent record
6 only built in editing facility is 'delete last character'	can have sophisticated editing facilities built into the terminal

A cassette recorder is the simplest form of backing store which is used to store large amounts of data program. Data is stored in serial form, 1's and 0's being represented by different frequencies being recorded. Cassette storage is a slow form of storage but is cheap.

(c) Memory

RAM: Random Access Memory. This is a memory in which all addresses can be reached at random i.e. without needing to scan the memory in any predetermined order to find a particular address. The microprocessor can read words from the memory or write words into the memory. It is normally used for the storage of data or for a program that is read from cassette tape into RAM used as the working storage of the computer.

ROM: Read Only Memory. This type of memory has values written into each location during manufacture; these values cannot be changed. It is used for storing information that will never need to be changed, such as look-up tables for character generation and program stores in dedicated systems.

PROM: Programmable Read Only Memory. A type of ROM that is supplied by the manufacturer with nothing written into it. The user puts the data into the PROM but once it has been written it cannot be altered. PROM are used for such things as the permanent storage of a program.

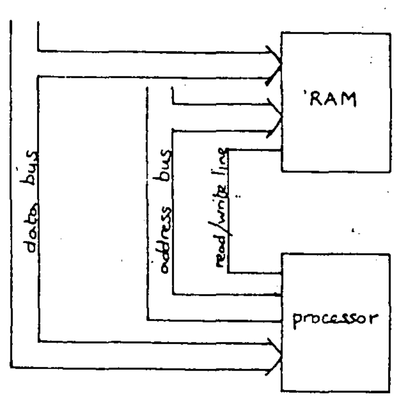
EPROM: Eraseable PROM. EPROMs are used for development work. Data written into them can be erased by exposing the integrated circuit to ultra violet light. However, it is important to realise that the memory acts as a ROM when used in the microprocessor system since the processor cannot change data stored in the memory.

(d) Bus Connections

Microprocessors are organised on a bus structure. What this means is that all devices attached to the microprocessor are connected to two sets of lines (the address bus and the data bus) and one control line (read/write line). This was shown in the earlier illustration of the interconnection of the various components of a microprocessor system.

Operation of the bus is best treated by considering only a processor chip and a random access memory.

Memory is usually 'byte-organised': this is translated as meaning that each memory location stores an 8-bit word or 'byte'. The microprocessor accesses a location by putting the address of the required location on the address bus. If the read/write line is set to 'read' the data stored in that memory location will be transferred to the data bus, and hence the processor. If the processor chip sets the 'read/write' line to 'write' the processor puts data onto the data bus and this data is written into the required address.



Each bus is a set of wires so that data or an address, appearing on the bus does so as a 'parallel word'. At the time of writing these notes (1979) it is common for a microprocessor system to use an 8-bit data bus and a 16-bit address bus. However, for the purposes of this syllabus it may be more appropriate to consider a more simple system using less bits.

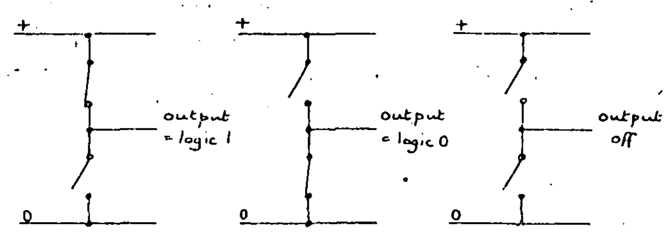
Points:

(i) RAM sizes are usually given in 'K bytes': 1 K (capital K) = 1024 (2^{10}) not 1000

(ii) a RAM chip will have one data part and one address part. Decoding of the binary address to select a particular location is done by logic on the RAM chip.

(e) Tri-state output

Logic gates considered in an earlier section of the syllabus have two possible output states: 1 or 0. However, when a number of outputs are connected to a common bus it is necessary to be able to switch off the outputs not required. The tri-state output stage has 3 possible output stages: 1, 0 or off. These 3 states are obtained by using two active devices (usually MOS transistors) in the output stage. Either active device can be switched ON when the other is OFF; both can be OFF; but it is impossible to switch both ON at the same time.



Use of Computers

Of the applications listed in this section the only one that might be unfamiliar to teachers is the incorporation of a computer (microprocessor) in complex equipment, an application that is becoming more common. Many visual display units are now using a microprocessor (rather than 'hard-wired' logic) to produce a simpler electronic circuit. The complexities are handled by the program and modifications can be made by simply changing the program.

Social Impact of Computers

Candidates may be required to write an answer discussing the social consequences of the large scale use of computers, particularly microprocessors. Such an answer would be marked on the logic of the argument and the inclusion of relevant examples; it would not matter if candidates adopted a pro-microprocessor or anti-microprocessor approach.

2.12 SAFETY (Syllabus section 1)

In a well run laboratory in which students are using equipment running on low voltages the most likely cause of accident is the soldering iron. However, these same students will, if the course is successful, almost certainly pursue their interests at home and many will use their knowledge in professional activities. It is therefore vitally important that students are trained into habits which will protect them when the currents are high and the voltages lethal.

ection 4.2 indicates the physical arrangements ecessary in working areas to conform to good ractice and it is hoped that teachers will ensure hat students are aware of all the safety rovisions of which they have the benefit. ection 7 of the syllabus includes those areas hich are directly and immediately relevant to the tudent following the course and which may be xamined.

t should be noted that question (ix) (d) in the roject assessment is also an assessment of what s in fact an essential prerequisite to safe orking.

urther guidance for teachers may be found in the ollowing publications recommended by the Health nd Safety Executive:

"The Safe Use of Electricity - a practical guide for persons at work in industry and commerce" obtainable from:

The Royal Society for the Prevention of Accidents
Cannon House
The Priory
Queensway
Birmingham B4 6BJ

(This publication is suitable for students to refer to, but contains much additional information that they do not need at this level.)

"Safety in Electrical Testing" obtainable from:

Radio Electrical and Television Retailers Association (RETRA) Ltd
RETRA House
57-61 Newington Causeway
London SE1 6BZ

The Health and Safety Executive also recommends the use of artificial respiration charts such as those published by Electrical Review.

BOOKS

here is at present no single book which can be used as a course book for either students r teachers. The following list is included to assist teachers in extending their own ackground knowledge and some of the books are also suitable for a reference library for udents.

ainly for Students:

roject Technology .... Basic Electronics, Books 1-5 .... English University Press

adybird 'How it Works' ...... The Telephone, Television, The Computer

(Slide sets for "The Telephone" and "Television" are available from Slide Centre Ltd, 143 Chatham Road, London SW11 6SR)

r Teachers' and Students' Use:

roject Technology .... Handbook No. 13 Basic Electrical and Electronic Construction Methods .... Heinemann Educational Books

gineering Science .... Electronics, Systems and Analogues .... Macmillan
velopment Unit (ESDU),
ughborough University of
chnology (for Schools Council)

W Owers .... Electronics - An Elementary Introduction for Beginners .... Publication Mailing Services, PO Box 6, Crawley, Sussex, RH10 6LH

C Pittman .... Design of Digital Systems (6 volumes) .... Cambridge Learning Enterprises

P Gane & A W Unwin .... Digital Computer Logic & Electronics (4 volumes) .... Cambridge Learning Enterprises

rranti .... E-Line Transistor Applications

rtley Jones .... The Practical Introduction to Electronic Circuits . Cambridge University Press

Plant (NCST) .... Photocell Applications .... English University Press

Plant (NCST) .... Operational Amplifier Applications .... NCST Trent Polytechnic, Nottingham

n R Sinclair .... Understanding Electronic Circuits .... Fountain Press

n R Sinclair .... Understanding Electronic Components .... Fountain Press

W Hellyer & I R Sinclair ... Radio and Television .... Newnes Technical Books

L Squires & C M Deason ..... Beginner's Guide to Electronics .... Butterworths

rdon J King .... Beginner's Guide to Television .... Butterworths

G Barker .... Foundation Electronics .... Nelson

Gordon J King	Beginner's Guide to Radio	Butterworths
Gordon J King	Guide to Printed Circuits	Fountain Press
Ian R Sinclair	Introducing Amateur Electronics	Fountain Press
Ian R Sinclair	Introducing Electronic Systems	Fountain Press
P J Povey	The Telephone and the Exchange	Pitman

For Teachers' Use:

T D Towers	Elements of Linear Microcircuits	Butterworths
D V Morgan & M J Howes	Solid State Electronic Devices	Wykeham Publications
L J Herbst	Discrete and Integrated Semiconductor Circuitry	Chapman & Hall
G B Clayton	Operational Amplifiers	Butterworths
Open University	TS282 - Electromagnetics and Electronics	Open University
W Gosling	A First Course in Applied Electronics	Macmillan
Ralph J Smith	Circuits, Devices and Systems	Wiley
E Huggins	Microprocessors and Microcomputers	Macmillan

Books on microprocessor technology become out of date more quickly than those on other aspects of Electronics. For books on this subject teachers should obtain the current lists prepared by the British Computer Society.

4 EQUIPMENT AND FACILITIES

4.1 TYPICAL REQUIREMENTS

The following suggestions are based on a group of 20 students:

Oscilloscopes

5 (minimum) oscilloscopes, at least one being a good quality double beam instrument. Experience suggests that schools should work towards one oscilloscope for each pair of students eventually.

Meters

5 .... multimeters (one between each pair of students might well be desirable)

1 .... high quality high impedance voltmeter (10 MΩ or better)

10 .... laboratory 100 μA meters with range of plug-in shunts (e.g. Unilab series)

For reasons of safety and good practice leads used with laboratory meters should be provided with proper insulated test probes.

Generators

2 (minimum) simple a.f. oscillators giving sine or square wave outputs and having controllable output between .1 mV and 5 V.

If it is anticipated that students will be using generators in individual assignments then a minimum of five generators will be essential.

Power Supplies

10 (minimum) power supply units will be required, on the assumption that students work in pairs on assignements. Outputs of 5 V, 500 mA and ± 12 V, 100 mA will be required, and two (minimum) variable voltage output units giving 0-15 V, 500 mA should be available. Short circuit protection is very desirable.

This minimum provision may involve sharing for project work.

The choice between bench mounted and portable supplies will be determined by individual conditions.

Circuit Boards, Bread-boarding

Some form of circuit boarding, e.g. S-Dec, should be available for experimental circuits, and some plug-in systems, such as Locktronics, or the Trent-Danum Electronics kits, will be useful for demonstration work. Veroboard or similar strip-board should be available in sufficient quantity for projects.

Several manufacturers, e.g. Unilab, supply boxed interconnectable units containing operational amplifiers, logic circuits, etc., which are valuable for assignments and demonstrations.

Equipment for Optional Topics

Needs will vary according to the topic chosen, but it is expected that candidates will be able to see and operate at least some of the devices and systems included. If the computing topic is selected, it is certainly desirable that candidates should see, and preferably use, a simple micro-computer system. Such a system need only contain a small amount of RAM and be operated through machine instructions in order to demonstrate the principles involved. Such equipment is available for as little as £60 (1979 prices).

Other components

Once an adequate stock of components for the teaching and laboratory assignment programme has been obtained, it is probably more economical in the first year or two to arrange that money is in reserve to purchase other components - particularly for project work - as becomes necessary. Components by return of post service, do cost a little more but you do not have the cost of a large unused stock to find. The necessary stock soon builds up and recurrent needs soon become apparent.

Storage

Three kinds of storage will be needed: for equipment for part completed projects, and for small components. Standard "tidy boxes", one for each student, are usually convenient for projects and will stack in cupboards easily. Small components are best stored in an array of small transparent plastic drawers e.g. those supplied by R.S. Components.

'ools

t a minimum, each pair of students will need
small screwdriver, a wire stripper or pair of side
utters, a small pair of narrow-nosed pliers, a
5 W soldering iron with a supply of solder, a
tand for the iron and a heat resistant mat.

n addition, a range of tools such as a fine
oothed saw for cutting circuit boards, small
ice, range of screwdrivers, hand drill and bits,
everal needle files, a sharp (Stanley) knife,
teel rules and a fine flat file will be needed.
uts and bolts, solder, steel wool, 5 minute
raldite and spare drill bits will be among
onsumables.

osts

t 1979 prices, it is likely that the cost of
etting up the course would be around £2000, but
ost schools will have much of the apparatus and
quipment available already in the Science
epartment. Annual costs are not high, as it
hould only be consumables and small components
hat have to be replenished.

.2 HEALTH AND SAFETY LEGISLATION

he Health and Safety Legislation requires that
ll reasonable steps should be taken to protect
tudents and teachers alike from possible accident
r injury. This means that the a.c. mains supply
hould be installed to comply with IEE regulations,
nd should preferably include an earth leakage
ircuit breaker and a master trip. All mains
quipment should be earthed, or double insulated,
nd all equipment to which connections will be
ade should have an isolating transformer.
quipment containing an autotransformer (e.g. many
ariacs) is not acceptable unless also permanently
onnected through an isolating transformer.

ains equipment must be capable of isolation from
ne supply. Whilst an accessible plug and socket
ill achieve this, in practice equipment should be
itted with a switch.

ne Legislation also requires regular inspection
nd maintenance of equipment. Checking should
nclude regular checking of earth continuity and
esting or earth leakage circuit breakers.

n considering electrical safety other hazards
hould not be overlooked. These include portable
lectric tools, and risks of burning from soldering
rons and other electrical equipment. All working
paces should be equipped with carbon dioxide fire
xtinguishers.

THE NATURE OF PROJECT WORK

ne project is intended to develop the abilities
equired for problem solving - formulation of the
ature of the problem and a specification for its
olution, planning of the approach, identification
alternative solutions and their evaluation to
elect the optimum solution, realisation of the
olution by construction of appropriate hardware,
nd evaluation of that solution. Since the
ealisation of the solution is necessarily a time
nsuming process, it is inevitable that these
ills will not be adequately assessed in a written
amination, so the scheme includes an assessment
the project work.

follows from this need to make decisions that
e work done by each candidate must be unique to
e candidate and different from work carried out
others in the class. Each candidate should be
couraged to select his own problem and two
ndidates should not be allowed to attempt the
me topic unless their approaches to it are
monstrably and fundamentally different right
om the outset.

Published designs may well form the basis of a project, but if published designs are used, the approach must be appropriate to the aims of the course. Any piece of equipment built must be intended to perform a specified function, and it is entirely acceptable that a candidate should formulate a problem, find several possible published designs, and select the most appropriate design to meet the specified requirement. However it is not acceptable for this syllabus for a candidate to see an attractive published design, decide he/she would like to build it and then hope that it will do as a probject.

5.1 TIMETABLE FOR PROJECT WORK

Since the project often requires background knowledge on the more sophisticated parts of the syllabus, most teachers leave the project work until the end of the course. Typically, students would be encouraged to think about possible topics and to select an appropriate topic in the October before the examination. They are required to consider the implications and plan their initial approach, and then prepare a Project Brief for submission to the Board by 30 November. This Brief is intended to direct the planning of the project and to ensure that the selected topic will be appropriate for assessment. It is not assessed at this stage, but will be signed by the Moderator and returned by January (see Section 6). It is assessed with the final report and must be resubmitted at that time (see Section 10). The Project, together with the candidate's report, will need to have been completed and assessed by the teacher so that it can reach the Moderator not later than 15 May.

For candidates preparing for the examination in one year, 30 November will be too early in the course for submission of a Project Brief. In this case it will be necessary to request permission from the Board, not later than 30 November, to submit the Project Briefs later. In this case, the Project Briefs must be submitted not later than 31 January.

Whilst individual cases vary by a considerable amount, typically a student might spend eight weeks in preparation, requiring perhaps a half hour of class time each week, and twelve weeks carrying out the project, based on two hours class time per week. Candidates might well expect to spend a significant amount of their own time on their projects - either in school after hours or at home.

5.2 PROJECT TITLES

There is not a list of standard titles, and candidates should be encouraged to find their own ideas. The following list of popular project titles is included only to give some indication of the scope of typical projects:

Electronic metronome

Stylus organ

Musical door chime

Guitar effects units

Windscreen wiper delay

Electronic dice

Electronic cricket

Pattern generator for oscilloscope

Programmed light display (low voltage only)

Enlarger exposure meter

Colour temperature meter

Stop clock

Transistor and diode tester

Capacitance meter

Combination lock

Automatic porch light

Burglar alarm

Rain warning device

Darkroom thermometer with audible output

Motor cycle anti-theft device

Telephone amplifier

Intercom

Sound projector slide change programmer

5.3 PREPARATION FOR PROJECT WORK

Many of the demands that a project of this sort makes on a student are new to his or her experience. It is therefore very desirable that students have some experience of these demands during the course. Many of the necessary skills can be introduced as part of the teaching programme, such as realisation of a circuit from a diagram, test procedures, constructional skills and the interpretation of data. Teachers are strongly recommended to introduce these skills into their courses in the form of mini-project activities, allowing students to determine and later evaluate their own individual approach to these activities.

6 THE PROJECT BRIEF

6.1 PURPOSE OF THE BRIEF

The Project Brief has two separate functions. As a part of the course it is intended to ensure that the candidate consciously attempts to plan his approach to his project, but at the same time, it provides an opportunity for the Board to reject suggestions for project work which would lead the candidate to an unfairly low assessment because of the nature of the work undertaken.

6.2 APPROVAL OF PROJECT TITLES

Every candidate is required to submit a Project Brief, using the special form EL1 supplied by the Board. There are two versions of EL1, one for candidates who will be assessed at the school or college and the other for private or external candidates whose work cannot be assessed by a teacher or supervisor at the examination centre. These forms will be sent when provisional entry is made in October (see Section 10), or on request. The forms set out in detail what is required.

Completed Project Briefs must be submitted to the Moderator. Schools and colleges send completed Project Briefs direct to the Moderator (his address will be sent with the supply of EL1's). Private candidates send their completed Project Briefs direct to the Board to be forwarded to the Moderator. The Moderator will check the proposal to ensure that it is of appropriate standard, suitable for assessment, and appropriate to the time available. He will approve or reject it on these criteria. He will not check for accuracy or make any assessment at this stage. If he rejects it he will indicate his reasons and the candidate will have to modify or change his proposal and submit a further Project Brief.

6.3 MODIFICATION OF APPROVED PROPOSALS

Once approved, a candidate may not alter the title or specification of the project in any way. The candidate's evaluation of the final project must be based on comparison with the specification given at the outset (if it does not compare favourably, his evaluation will indicate this and offer reasons). If a candidate does wish to change the title or specification, a second Project Brief must be submitted. Other details given on the Brief may be amended by the candidate as the project progresses, but reasons for the modifications should be given in the report. It is fully recognised that the candidates' first thoughts may not be their best ones, but it is inherent in the approach of this course that candidates should formulate ideas at the start of an activity. It is suggested that the candidate's responses to the questions on the Project Brief may often provide the opportunity for the teacher to discuss the proposals with the candidate in a purposeful and educative manner.

6.4 ASSESSMENT OF THE BRIEF

The Brief is not assessed when it is first submitted since its value in the development of the Project is as a starting point. It is essential, therefore, that the approved Project Brief is re-submitted with the final project report for assessment. When the Brief is returned to the Centre by the Moderator, it is important that it is not lost and it may be advisable for the Centre to provide candidates with a copy of their Brief whilst keeping the original in a secure place. IF A FINAL REPORT IS SUBMITTED WITHOUT AN APPROVED BRIEF, THE PROJECT WILL NOT SCORE MORE THAN 25 MARKS OF THE 50 AVAILABLE. NO ASSESSMENT WILL BE MADE IN GROUPS (III), (IV), (V), (VI), (VII), (X), (XI) AND (XII).

6.5 LATE SUBMISSION OF PROJECT BRIEFS

Project Briefs should reach the Board not later than 30 November preceding the examination. Project Briefs may be accepted after this date AT THE DISCRETION OF THE BOARD. Where candidates are attempting the subject in one year, a request should be made to the Board, before 30 November, for later submission of the Project Brief. In these circumstances approval will normally be given for receipt of the Brief by the Board not later than 31 January preceding the examination.

UNDER NO CIRCUMSTANCES WILL A BRIEF BE ACCEPTED AFTER 1 MARCH, SO THAT LATE ENTRY FOR THIS SUBJECT WOULD ALWAYS CARRY A PENALTY IN THE MARK FOR THE PROJECT. Similarly, re-submission of unapproved Briefs or modification of approved Briefs will not receive approval after 1 March.

7 ASSISTANCE TO CANDIDATES

7.1 ADVICE BY TEACHERS

Project work represents a teaching situation as well as the preparation of work for assessment, and it is accepted that a teacher will need to give advice and assistance to candidates as part of that teaching progress. In doing so, teachers should:-

(a) provide information - preferably with alternative possibilities included - in such a way that the candidate has still to make his or her own decision on accepting or using the information given

(b) ensure that the candidate acknowledges the help given in his or her report

(c) keep a record of any significant help given to a candidate and note this on the assessment form when assessment is made.

7.2 INFORMATION ON ASSESSMENT PROCEDURES

Centres are asked to show candidates a copy of the project assessment scheme, and to explain how it operates. This should be done before the Project Brief is submitted. To a significant degree, assessment puts project work into an engineering context. It may be useful to set out the reasoning for this assertion.

In a true engineering situation a customer would ask for a device or equipment to satisfy some purpose and would provide a specification for the equipment. That specification would include technical requirements but also requirements in terms of cost, materials, size etc. In terms of the project itself, the teacher may, in some circumstances, furnish some of these "customer demands", but in most cases they will be determined if at all, by the candidate. The assessment procedure, however, provides a genuine customer demand with the Board acting as customer and the assessment scheme providing the customer's specification.

7.3 ASSISTANCE FROM OTHER SOURCES

Candidates are expected to consult reference books or experts as appropriate. In every case they must acknowledge this source of information or advice explicitly (either as a footnote or as a list of references). The project assessment is based on what they have done with the information at their disposal,,not on the facts and information they claim to know.

8 GROUP PROJECTS

Group projects are not permitted in this subject.

9 PROJECT REPORTS

At the end of the project each candidate must prepare a report on the project. This report will be assessed, together with the hardware of the project, by the teacher, and then the report will be sent to the Moderator. The reports will not be returned.

9.1 CONTENT OF REPORTS

The report should contain:

(a) The Project Brief

(b) A statement of alternatives considered for the chosen artefact and the reasons for the selection of the particular design chosen. Reasons for deviation from the original Project Brief should be included.

(c) Significant aspects of development and progress

(d) A brief explanation of the mode of operation of the artefact (either in words or by diagrams)

(e) Test results, appropriately tabulated

(f) An evaluation of the performance of the artefact based on the original specification

(g) Layout diagrams, circuit diagrams, photographs, etc, to illustrate both the development and the final form

(h) Statement of all sources of information and assistance received.

As much of the report will be in the form of diagrams, tables etc, it is difficult to give an estimate of the typical length of a report. However, it is unlikely that a report will be more than 2000 words in length. It is more important that the report should be of a length appropriate to the project whether this is less or more than the typical length. Candidates will lose marks for including unnecessary detail, for unnecessary repetition, and for failing to include essential details.

9.2 STYLE OF PROJECT REPORT

The style of the report should be, before anything else, clear straight-forward communication of facts and ideas. Candidates should be given instruction in the presentation of information and encouraged to use a more suitable style than a simple diary of events. The quality of written communication is directly assessed but its real weighting in the assessment is inevitably greater than the marks directly allocated.

10 PROJECT ASSESSMENT

In order that arrangements can be made for Project Assessment, a provisional entry for this subject must be made by 15 October of the year preceding the examination, by writing to The Secretary General (A7) at the Board.

The completed Project Report must reach the Moderator by 15 May. Every candidate must have carried out a project and submitted a Project Report. No result will be issued unless a Report is submitted and some hardware has been produced.

10.1 ADMINISTRATIVE DETAILS - CANDIDATES ASSESSED AT THEIR OWN CENTRE

The first assessment of the project and its report is to be carried out by the teacher using the detailed scheme and assessment form provided by the Board.

Assessment forms will be sent to centres in early April. Assessment must be completed and the project report and assessment forms (but not the project hardware) must be sent to reach the Moderator by 15 May. The Moderator may wish to visit the centre to inspect the project hardware (and possibly interview candidates) during the period 15 May to 30 June.

Centres may obtain copies of the assessment scheme at any time by applying to the Secretary (A7).

10.2 ADMINISTRATIVE DETAILS - PRIVATE CANDIDATES

The assessment of the project report will be carried out by the Moderator using the same scheme of assessment as used for internal candidates. When the report has been assessed, the candidate will be required to attend for an interview with the Moderator at a centre and on a date to be arranged by the Board. All interviews will be completed by 15 June. The Moderator may ask the candidate to bring his project to the interview. An additional practical fee will be payable by private candidates.

Private candidates must send their Project Report (but not the project hardware) to the Moderator to arrive not later than 15 May. The Moderator's address will be notified in April. All other correspondence must be sent to the Board at this address:

The Secretary General (A7)
Associated Examining Board
Wellington House
Station Road
Aldershot
Hampshire GU11 1EQ

Private candidates can obtain a copy of the assessment scheme, for their own reference, by applying to the above address.

10.3 BASIS OF ASSESSMENT SCHEME

The assessment scheme uses groups of graded questions which are to be given either a 'yes' or 'no' answer, and the mark awarded is the number of 'yes' answers obtained by a candidate. However, the questions are arranged in groups and 'yes' answers may only be given to later questions in a group if all previous questions in the group have gained a 'yes' answer - even if by itself the question would obtain a 'yes' answer.

The answer to the assessment questions given by the teacher must be based on evidence from the project hardware and the project report. Where a candidate clearly deserves a particular mark but has failed to record the necessary details in his report, the teacher can award a mark providing supporting information is given to the Moderator.

GROUP IX

Questions (a) and (b) are determined by visual inspection alone, without reference to circuit diagrams. However, a probe such as a screwdriver blade will reveal dry solder joints most effectively. Acceptable standards for (c) include a correct mounting on circuit boards, with values visible.

In order to obtain a 'yes' for (d) it should be possible to use a multimeter, signal generator or oscilloscope in conjunction with the project without risk of shorting other connections or inability to trace specific points of a circuit reliably.

GROUP X

This section of the assessment deals with checking procedures during the construction or development of the project. In the case of a circuit or system being designed from basic units the main significance of this section is obvious. In the case of construction based on an already proven circuit for which development work would be inappropriate, the candidate is still expected to be sure that components are of the values they purport to be (particularly important if second-hand components are used), that supply voltages are correct, that appropriate continuity tests are made, and so on. In addition, it is rare even with proven designs that every component is exactly the correct size, shape and value and modification becomes necessary.

Whatever the testing or modification required, some brief indication of what has been done should appear in the report, and two marks should not be given unless this is so.

GROUP XI

Evaluation of system performance is only relevant in the context of the specified function and/or purpose of the artefact.

GROUP XII

This section is concerned with the final checking of the finished artefact and refers to the specification. Question (b) depends on the way the test equipment is used or measurements are made. Question (c) depends on the conclusions drawn from these procedures, and should be given 'no' if unsupportable claims are made. However, the statement that the artefact does not meet certain specifications should, if correct, get credit.

GROUP XIII

The candidate inevitably needs help from the teacher in completing the project and since the project activity is an integral part of the teaching process, such help should be given. This assessment is concerned with who makes the decisions. Good candidates might be told the range of possible solutions to a specific problem by the teacher, but they would decide which solution to adopt on their own responsibility, acknowledge the source of the information, and get three marks. A poor candidate will have to be told what to do, and the marks will be low in this section in consequence.

GROUP XIV

Originality means in this context the introduction of ideas new to the candidate and originating from his/her own thinking and research.

GROUP XV

Any instance of the adverse circumstances noted in questions (a) and (b) must be penalised. It is hoped that teachers will welcome the opportunity to set a high standard in these areas.

11 SYMBOLS

The systems of symbols that will be used in question papers are given below. Other systems, if clear and consistent, will be acceptable in candidates' scripts or project reports, but it is hoped that candidates will be encouraged to use the systems indicated below.

11.1 TEXT SYMBOLS, SUBSCRIPTS ETC.

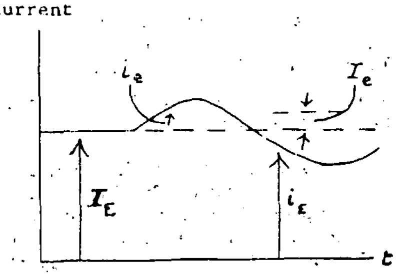
Where letters are used in equations to represent quantities, the letters will be printed as italics. Where letters are used as labels, they will be printed in roman type. Thus R is a value of resistance in ohms (or any other unit) whereas R is a label for a resistor. (Symbols will be in accordance with those indicated in the ASE publication "SI Units, Signs, Symbols and Abbreviations.")

Quantity Symbols:

Quantity symbols published in the syllabus and in examination questions will follow the practice laid down in BS 3363. Candidates will not be penalised for a different usage provided that it is clear and unambiguous. The advantage of BS 3363 is that it clearly distinguishes between the varying and constant components of a signal. A quantity symbol generally consists of both a main symbol and a subscript, the main symbol denoting the quantity and the subscript the part of the circuit to which it refers. Different cases are used to distinguish different components of the signal:

	Quantity symbol	Subscript	Meaning
a)	lower case	lower case	instantaneous value of the varying component
b)	lower case	capitals	instantaneous value of the total signal
c)	capitals	lower case	RMS value of the varying component
d)	capitals	capitals	DC value (no signal)

e.g. emitter current



With a 3 terminal device, such as a transistor, 3 subscripts are used:

1st: terminal at which quantity is measured

2nd: reference terminal or symbol to indicate configuration of circuit (may be omitted if meaning is clear)

3rd: indicates state of the 3rd terminal

- X - reverse biased
- O - open circuit
- S - shorted to the reference terminal (2nd subscript) (omitted if the third terminal is not necessarily in one of these conditions)

10.4 AMPLIFICATION OF ASSESSMENT QUESTIONS

GROUP I

This assessment is based entirely on the written report. The development of a project will vary significantly dependent upon its particular nature. In some cases it will be the trying out of circuits on bread-boards or the testing of sections of a system. In other cases it will be determining physical arrangements (e.g. possible vero-board designs) and the testing of components. Whatever form the development takes, it should be reported.

GROUP II

This assessment is based entirely on the written report. A single circuit diagram is not sufficient for 'yes' for question (a), but question (a) may be answered 'yes' if there is any additional attempt to use appropriate sketches etc. Reproduction of standard basic circuit diagrams taken from the test book are not, by themselves, likely to score more than one mark in this section, since a page reference to the original circuit could be equally appropriate.

GROUP III

This assessment is based entirely on the written reports. Evaluation of a system performance is only relevant in the context of the specified function and/or purpose of the artefact.

GROUP IV

Available resources means libraries in school, accessible experts, readily available magazines and the local library if it is accessible and can supplement resources in the school. To score two marks there should be no obvious reference which the candidate has failed to check.

GROUP V

A details specification means a specification giving the complete sequence of a sequential or oscillating system, an indication or range of control function and indication of power supply requirements and an indication of conditions under which the artefact is to operate. Question (c) may be answered 'yes' if any of the parameters in the specification is specified in quantitative terms.

GROUP VI

The assessment sheet indicates the type of parameters required, and below is given some indication of the range of parameters that could be considered for typical projects. The operation of questions (b) and (c) can perhaps best be explained by an example. The standard for (b) is "The power supply voltage is to be 9 volts" whereas for (c) "The power supply should be between 7.5 volts and 9.5 volts." The requirement for a realistic range is only to be operated as a discriminator against candidates who know a range of values might be the correct specification but specify any range that comes to mind solely to "earn" the mark. It is, in any case, important that candidates specify in realistic terms because their evaluation techniques will follow from the specification and this scheme will tend to penalise an unrealistic specification inadequately evaluated. It should also be noted that this question will tend to penalise the very simple project, and therefore sets the lower limit of acceptable complexity, but will accommodate both a simple project thoroughly evaluated and a more complex project with less evaluation.

Examples of parameters which might be specified:

(i) metronome

frequency range, mark/space ratio, stability, power requirements, output power, setting accuracy

(ii) traffic light sequence generator

time for red, time for red/yellow, time for green, time for yellow, power requirements, light output, timing controls, switching times.

(iii) audio amplifier

input signal, amplifier gain, input signal control, output power, output load, frequency response, distortion, power requirements, low frequency correction, high frequency correction, safety or overload protection.

(iv) windscreen wiper delay unit

delay time, control, power supply requirements, motor stall protection, response to variation in supply voltage, timing stability, temperature stability, protection from adverse environment.

(v) radio receiver

frequency range, selectivity, sensitivity, output power, automatic/manual gain control, power supplies, signal/noise ratio, hum levels, stability.

Teachers are reminded that students are expected to use reference sources in this and all parts of the project. They are not expected to derive quantitative specifications from their imaginations.

GROUP VII

"Any evidence" means that a single instance of alternatives being considered, chronicled in the report, will earn one mark. "Several relevant points" means at least three instances. Design solutions means complete circuits taken from reference sources.

GROUP VIII

An assembly which is not sufficiently rigid to be transported in one piece, or in which electrical connections are intermittent, cannot score more than one mark. Redundant material includes unused circuit boarding, excessively large cabinets, unnecessary switches, controls or warning lights, unnecessarily heavy conductors, unnecessary earth loops, leads of unreasonable length. High standards of neatness are required, including wiring neatly bunched, routed and colour coded and a good standard of craft practice in construction. Cabinets are not necessarily required for all projects. If equipment is mains operated or is to be used in circumstances where protection is required, then a cabinet would be expected, but low voltage equipment would often be 'complete' without provision of a cabinet.

Circuits do not necessarily need to be built as a permanent piece of equipment. Construction based on bread-board systems or matrix board is acceptable provided (a) the assembly is organised (b) the assembly will withstand movement and storage. As a guide to the latter condition, the equipment should be capable of being moved from bench to storage cupboard and back without need for dismantling or introduction of faults.

The supply voltage is denoted by repeating the subscripts:

Examples: i_b: instantaneous value of the varying component of base current

v_{CE}: instantaneous value of collector-emitter voltage

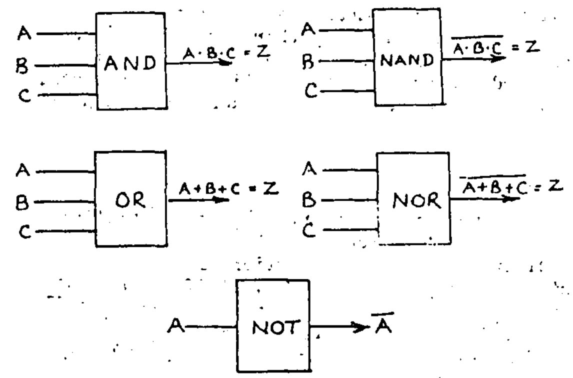
V_{CC}: supply voltage (the supply connected through some network to the collector terminal)

11.2 CIRCUIT SYMBOLS AND CIRCUIT DIAGRAMS

Diagrams published in the syllabus and in examination questions will be to BS 3939. However, it is recognised that some of the symbols in this standard are not those in common use. Candidates must *recognise* BS 3939 symbols but will not be penalised for using something different in their answer if their usage is clear and unambiguous.

11.3 LOGIC - SYMBOLS

To preserve simplicity and uniformity, the system of symbols used for the purpose of the examination is outline below.



A D D E N D U M

The following notes were prepared by the Chief Moderator as part of his report on the first examination in 1982.

THE PROJECTS

The standard varied from excellent in concept to crude in the extreme. Although the course is based on a systems approach, it was disappointing that few projects were manifestations of this approach. Most projects were "lifted" directly from electronics magazines; teachers are advised to ensure that the circuits do not contain errors (the latter may be corrected in subsequent issues of the magazines). There was little evidence of testing during construction, i.e. testing on a modular basis.

It is recommended that more advice be incorporated in the course, with reference to:

(i) Layout, both of components and of the whole project (problems occurred where the circuit was fixed to the bottom of the box, and interconnecting wires went to controls on the top of the box).

(ii) Colour coding of interconnecting wires.

(iii) The comparative advantages and disadvantages of perforated board, stripboard (or Veroboard), and printed circuits. Many problems arose through bridging, or unwanted connections, or poor contacts, when stripboard was used. Few candidates made their own printed-circuit boards.

With effect from the 1983 examination, the following projects will NOT be accepted, for the reasons stated:

(i) Citizens Band Transmitters, transceivers or amplifiers; these devices are not acceptable because each one MUST be Home Office approved, and carry the stamp of approval.

(ii) Disco-flashing lights; these are not acceptabl because they involve the switching of power levels of several hundred watts. However, the principle could be demonstrated by the use of LED's.

(iii) Any device connected directly to the mains supply without the use of an isolating transfo

Where a mains operated project is proposed, it must confo with current Regulations, both national and local. Furth a mains operated project must: (a) be built in a metal bo (b) contain suitable fuses on the input and output circui (c) have a neon indicator which lights when the project i plugged into the mains, i.e. before any switch, (d) have an isolating transformer, (e) use 3 core cable for connec to the mains; this cable must have a secure cable grip (a knot will not suffice), (f) incorporate a D.P.S.T. switch in the primary circuit, (g) have circuit boards and all components firmly bolted in position, and (h) provide adequate physical and electrical separation between the mains, and the low voltage circuit.

PROJECT REPORTS

It is suggested that candidates be given advice by teache (perhaps when doing mini-projects) of the requirements, i.e. in the technique of report-writing. It must be emphasised that the Project Report is the only evidence available to the Moderator of what has actually been done In the 1982 examination there was little evidence of alternative solutions to the problem being considered, the development of the project was rarely reported, eithe in writing or in diagrams, and rarely did a candidate stat clearly whether the Project did work, partly or complete! Some reports contained large sections extracted and copi directly from magazines, often with phraseology that was incomprehensible to candidates!

Photographs included in the report should show clearly constructional details of the project. A photograph of the candidate working on his project is not required, an a photograph of a box or cabinet with projecting control is not by itself adequate. All photographs must be firm mounted in the report (loose photographs fall out and no then knows to which Report they belong).

The reports contained little evidence of testing during development. Few candidates named the test instruments used, or gave any indication of the readings obtained. This is considered an essential feature of electronics, together with a tabular presentation of readings and results.

Candidate Number

THE ASSOCIATED EXAMINING BOARD

for the General Certificate of Education

ELECTRONICS (080)

Ordinary Level

PROJECT BRIEF

NAME OF CENTRE: ______________________

CANDIDATE'S SURNAME AND INITIALS: ______________________

YEAR OF EXAMINATION: ______________________

FILL IN YOUR CENTRE AND CANDIDATE NUMBERS IN THE BOXES IN THE TOP RIGHT HAND CORNER OF THIS COVER

A Project Brief form must be completed by each candidate for the examination, and the forms must reach the Board's Moderator not later than November 30th preceding the date of the written examination, together with the top copy of the candidate list, CT2/EL2.

Candidates are strongly advised to keep a copy of the Project Brief form, so that preparatory work can be carried out while the Moderator has the forms.

Project Briefs will be returned to centres by January 1st with any necessary comments by the Moderator.

When you have completed this Project Brief, make sure you have a copy for your own use and then hand the original form to your supervisor so that he can post it to the Moderator.

SUPERVISOR'S DECLARATION

I confirm that this Project Brief has been prepared by the above candidate.

Signed: ....

Date: ....

1983

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1. What is the title of your project?

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2. Write a specification for the completed system you intend to produce.

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3. Give some indication of the type and range of the materials, components and equipment you think you will require for the conduct and completion of your project.

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4. Can you think of any special difficulties you may have to meet during your project work? Indicate your provisional plans for overcoming them.

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5. Make an estimate of how many weeks you think it will take you to complete the project, and of how the time will be divided up between the various stages.

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6. Make a list of the sources of information (including advice from other people) you are using, or think you may need to use, in your project activities.

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7. Outline any tests you intend to apply to your completed system.

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USE THIS SPACE FOR SKETCHES, DIAGRAMS OR OTHER INFORMATION IF REQUIRED.

NOTES FOR GUIDANCE OF CANDIDATES

The space available on the form is an indication of the amount of detail you are required to give. In exceptional circumstances only, an additional sheet of plain paper may be added if enough space is not available, and this extra sheet must have your name on it and be firmly stapled to this Project Brief.

In completing this Project Brief you should also consider what you are expected to do for the final report on your project. Your supervisor will show you a copy of the Project Assessment Scheme which will be used to mark your project at the end of the course, and you should ensure that as far as possible you will be able to obtain "Yes" answers to all the questions in the assessment scheme.

The specification in section 2 should consist of a description of the function of the completed system and a statement of the values of all significant quantities which are predetermined, a statement of the range of all quantities which are variable or can have a range of values, and a statement of the sequence of any sequential operation giving times for each element of the sequence. The specification is a statement, as complete and precise as you can make it, of what the completed system is intended to do, and this is the measure by which you will be able to judge how effective your completed system is at the end of your work. You will not get extra credit by trying to be excessively precise or, on the other hand, by making the specification so broad that the completed system will inevitably meet it. High marks will be awarded for a realistic specification, a realistic attempt to meet it, and a sensible appraisal of how far and in which respects you have achieved it.

The information you give in sections 3 – 7 inclusive on this form does not irrevocably commit you to particular courses of action. Where major changes are necessary in the way you carry out the project, you should make detailed comments about the reasons in your project record which you hand in at the end of the course. Any major divergence from section 1 or 2, however, must be negotiated by your supervisor with the Moderator.

Project Brief Approval

When the Project Briefs are returned approval will be indicated in the appropriate space on page 6 of the form. Should the Moderator not approve, he will give reasons and you should submit a new or modified Project Brief for approval before January 20th. This will normally be returned within a few days. It should be pointed out that approval only means that the activity planned, if fully carried out, will give an assessable project at Ordinary Level. Approval does not mean that the Brief is flawless or that further planning is unnecessary.

This Project Brief is: approved

not approved

Comments:

Signed: ....
(Moderator)

Date: ....

NOTE

Approval by the Moderator indicates that the project is appropriate for the examination in Electronics but does not indicate that every detail in the Brief is necessarily correct or appropriate.

In making a final assessment of the project, the initial brief will be taken into account.

CT2/EL2

ASSOCIATED EXAMINING BOARD
for the General Certificate of Education

Subject .... Level ....

Centre Number .... Centre Name ....

Centre Address ....

.... Centre Telephone Number ....

Name of Teacher in charge of the subject ....

Month and Year of Final Examination ....

I am enclosing Project Briefs for approval from the candidates listed below.

Signed .... Date ....

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Candidate's Name	Project Title	For Moderator's Use

If there is any special information of which the Moderator should be aware, please comment on a separate sheet of paper and attach the sheet to this form.

THE ASSOCIATED EXAMINING BOARD

for the General Certificate of Education

ELECTRONICS (080)
Ordinary Level

PROJECT ASSESSMENT

The project is to be assessed out of a total of 50 marks.
The marks are to be allocated under the following criteria.

GROUP	CRITERION	MARKS
(i)	Written communication	5
(ii)	Graphical communication	3
(iii)	Reporting of System Performance	2
(iv)	Use of Resource Materials	2
(v)	Project Brief	4
(vi)	Specification	3
(vii)	Design, Selection of Alternatives	4
(viii)	Competence in Physical Assembly	4
(ix)	Competence in Electronic Assembly	5
(x)	Testing and modification during development	2
(xi)	Does it work? (Including reliability)	5
(xii)	Quality of evaluation	3
(xiii)	Project activity during the course, and initiative	3
(xiv)	Originality	2
(xv)	Safety	3

ASSESSMENT OF THE CRITERIA ABOVE

The questions are arranged in various groups according to the criteria being tested.

The questions in each group are graded, each question representing a higher ability than the preceding question in that group.

To assess a particular project, the teacher, on the evidence of the artefact, project report and his knowledge of the work of the candidates, will answer the questions. If the answer is 'yes' to a particular question, award 1 mark in the appropriate column, and proceed to the next question in that group. If at any stage a 'no' answer is recorded, the marks awarded for that particular question and remaining questions in that group are zero, and the teacher will proceed to the next group of questions.

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Group (i) – Written Communication (5 marks max.)

(a) Has the candidate reported at least some of the major aspects of the development and progress of the project?

(b) Has the candidate reported all the significant aspects of the development and progress of the project?

(c) Is the presentation of the report logical?

(d) Is the report clear (i.e. concise, free of unnecessary repetition, and easy to understand)?

(e) Does the report represent a complete account of all the work carried out by the candidate?

Group (ii) – Graphical Communication (3 marks max.)

(a) Is the development of the project illustrated by appropriate block diagrams/circuit diagrams/layout diagrams/photographs?

(b) Is the development of the project adequately illustrated by block diagrams/circuit diagrams/layout diagrams/photographs?

(c) Are the illustrations neatly and carefully presented?

Group (iii) – Reporting of System Performance (2 marks max.)

(a) Does the report contain any evidence of evaluation of system performance?

(b) Does the report contain evidence to show that the system performance has been evaluated fully, including tables of appropriate test results?

Group (iv) – Use of Resource Materials (2 marks max.)

(a) Did the candidate use a reasonable selection of available resources?

(b) Did the candidate make the best use of available resources to ensure that the project operated to the specification?

Group (v) – Project Brief (4 marks max.)

(a) Does the report contain a statement of a project brief in addition to the title?

(b) Does the Project Brief contain a specification for the main features of the proposed artefact?

(c) Does the Project Brief contain a quantitative specification for the proposed artefact?

(d) Does the Project Brief outline possible problems that need to be solved in order to arrive at a final solution?

Group (vi) – Specification (3 marks max.)

(a) The specification includes at least four parameters (e.g. input, transfer or output characteristics of the artefact, its power requirements, control functions, individual stages in a sequence, frequency ranges, signal purity)

(b) The specification includes at least four parameters for which magnitudes have been given.

(c) The specification includes at least four parameters for which the magnitudes are specified precisely and in realistic terms.

Group (vii) – Design, Selection of Alternatives (4 marks max.)

(a) Does the report contain any evidence to show that apparently feasible alternative solutions to problems, or alternative design solutions, have been considered?

(b) Does the report contain evidence to show that alternative solutions to problems or alternative design solutions have been considered at several relevant points?

(c) Has the rejection of alternatives been supported by sensible reasons in some cases?

(d) Has the rejection of alternatives been supported by sensible reasons in every case?

Group (viii) – Competence in Physical Assembly (4 marks max.)

Note: Assembly is to be taken to include any physical structure or physical mounting (e.g. circuit board, mounting arrangement for controls, connections or transducers, cabinet etc.)

(a) Is there evidence of organisation of the physical assembly?

(b) Is the assembly constructed to withstand adequately the hazards of normal use?

(c) Is the assembly free of redundant material?

(d) Is the assembly neatly constructed?

Group (ix) – Competence in Electronic Assembly (5 marks max.)

Note: Electronic assembly involves acceptable standards of layout, circuit board etching, soldering and connecting, component mounting, maintenance of insulation, etc.

(a) Is the artefact free of actual or potential construction faults detectable by visual inspection alone, including poor solder joints, bridged connections, overheated circuit boards, damaged insulation and components mounted with unduly long leads or under tension?

(b) Has the candidate ensured beyond his/her own and the Assessor's reasonable doubt that the circuit is correctly wired/laid out/connected before switching on any circuit power supply?

(c) Are all components mounted to acceptable standards?

(d) Is the circuit set out in a way which will allow diagnostic, maintenance and service checks, using available service equipment, to be carried out without physical difficulty?

(e) Are all connections (whether soldered or not) effected with negligible resistance and are all circuit boards (where used) designed and etched to acceptable standards?

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Group (x) – Testing and modification during development (2 marks max.)

(a) Did the candidate carry out suitable tests and modifications to the project at some stages?

(b) Did the candidate carry out suitable tests and modifications to the project at all relevant stages?

Group (xi) – Does it work? (Including reliability) (5 marks max.)

(a) Does any part of the project work in the manner specified in the design brief?

(b) Do several parts/sections of the project work in the manner specified in the design brief?

(c) Does the major part of the project fulfil the design brief and work even if only intermittently or with constant attention?

(d) Does the major part of the project fulfil the design brief and work regularly and reliably?

(e) Does the project fulfil the design brief and work reliably?

Group (xii) – Quality of evaluation (3 marks max.)

(a) In evaluating the artefact did the candidate carry out appropriate procedures?

(b) Were these procedures carried out accurately?

(c) Are the recorded conclusions accurate?

Group (xiii) – Project activity during the course, and initiative (3 marks max.)

(a) Has the candidate made at least some decisions on his/her own responsibility (although he/she may have needed direction in solving other problems)?

(b) Did the candidate solve most of his/her problems on his/her own responsibility (although possibly requiring direction on a few)?

(c) Did the candidate take all the important decisions taken?

Group (xiv) – Originality (2 marks max.)

(a) Has the candidate made any original contributions to the project?

(b) Is the candidate the main source of fruitful ideas?

Group (xv) – Safety (3 marks max.)

(a) Did the candidate adopt a safe approach to practical work? (i.e. the operation of the equipment did not result in immediate component failure, rapid overheating, electric shock or other physical accident)

(b) Did the candidate adopt a sensible approach to practical work by observing reasonable precautions to avoid electric shock, overheating or burning, and other physical hazards?

THE ASSOCIATED EXAMINING BOARD

CENTRE NUMBER					CANDIDATE NUMBER				DO NOT WRITE IN THE SPACE BELOW				
0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9	9	9	9

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SHOW REQUIRED MARK BY SHADING IN PANEL THUS ▯ TO CANCEL A MARK ALSO SHADE UPPER PART OF BOX ■

1 WRITTEN COMMUNICATION
a) some aspects 1 0
b) all aspects 1 0
c) logical 1 0
d) clear 1 0
e) complete 1 0

2 GRAPHICAL COMMUNICATION
a) illustrated 1 0
b) adequately 1 0
c) well presented 1 0

3 SYSTEM PERFORMANCE
a) some evaluation 1 0
b) full evaluation 1 0

4 RESOURCE MATERIALS
a) reasonable use 1 0
b) best use 1 0

5 PROJECT BRIEF
a) submitted 1 0
b) with specification 1 0
c) which is quantitative 1 0
d) problems outlined 1 0

6 SPECIFICATION
a) four parameters 1 0
b) with magnitudes 1 0
c) precise and realistic 1 0

7 DESIGN
a) alternatives considered 1 0
b) at several points 1 0
c) reasons for rejection 1 0
d) in all cases 1 0

8 PHYSICAL ASSEMBLY
a) organisation evident 1 0
b) adequate construction 1 0
c) no redundant material 1 0
d) neat 1 0

9 ELECTRONIC ASSEMBLY
a) no obvious faults 1 0
b) circuit checked 1 0
c) acceptable mounting 1 0
d) easily serviced 1 0
e) technique good 1 0

10 TESTING
a) at some stages 1 0
b) all relevant stages 1 0

11 DOES IT WORK?
a) any part 1 0
b) several parts 1 0
c) most of project 1 0
d) reliably 1 0
e) fulfils design brief 1 0

12 EVALUATION
a) appropriate procedures 1 0
b) performed accurately 1 0
c) accurate conclusions 1 0

13 PROJECT ACTIVITY
a) made some decisions 1 0
b) made most decisions 1 0
c) made all decisions 1 0

14 ORIGINALITY
a) any original ideas 1 0
b) most fruitful ideas 1 0

15 SAFETY
a) safe approach 1 0
b) sensible 1 0
c) thorough 1 0

NOTES

Use only an HB pencil to complete this form.
Write only in marked boxes.
Submit comments separately.
Code centre and candidate numbers at top of sheet.
Refer to EL3 for detailed criteria for each mark.
Mark either 1 or 0 for each of the 50 criteria.
Enter total mark and candidate's name in box on right hand side.

ELECTRONICS (080) PROJECT MARKSHEET

Moderator's total mark

Assessor's total mark

Centre (Enter centre name on first card in the batch)

Candidate's name

DO NOT FOLD THIS CARD

EL6

THE ASSOCIATED EXAMINING BOARD

ELECTRONICS (080)

Ordinary Level

PROJECT REPORT COVER

Centre Number
Candidate Number
Month & Year of Examination
Moderator's signature

CENTRE NAME: ....
(BLOCK CAPITALS)

SURNAME AND INITIALS: ....
(BLOCK CAPITALS)

TITLE OF PROJECT: ....

....

Notes to Candidates

(1) On this cover, fill in the name and number of your centre, your name and candidate number, the date of the final examination and the title of your project in the appropriate spaces above. Use block capitals.

(2) Check that your report contains:

(a) The Project Brief.
(b) The Report, which should include acknowledgement of all help received.
(c) One or more clear photographs showing constructional details of the project.

(3) The Moderator must have the original report. Copies, if required, must be made before the original is despatched to the moderator. This report will NOT be returned to you after the examination.

(4) The pages of your report should be numbered and either stapled or loosely tied together.

Record of Major Help Given and reasons for ticks in column 2 on EL4 (to be completed by the teacher)

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TEACHER'S DECLARATION

I confirm that the candidate's project report is based on the candidate's own work and that all work based on other sources has been acknowledged or is indicated above.

Signed: ....

Date: ....