The transmission of electricity in England and Wales: land use, and amenity aspects

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ABSTRACT

The Transmission of Electricity in England and Wales;
Land Use and Amenity Aspects:

Transmission of electricity is performed at 132, 275 and 400 kilovolts and is the responsibility of the Central Electricity Generating Board. The distribution of electricity at lower voltages is the responsibility of Area Boards. This thesis is solely concerned with the former. The first part deals with the historical development of the industry and the linking of many separate electricity undertakings, to provide economies from the reduction of spare generating plant, and security of supply. The factors determining the locations of coal, oil and nuclear power stations examined. The geographical pattern that results from the location of generating plant and of demand for electricity, determines the shape and size of the transmission network.

Transmission is effected by overhead lines and underground cables, and the effects of both on the use of land and on amenity are examined.

Substations are required to switch electricity from one circuit to another and to transform it between voltages. Because of their size and the engineering considerations affecting their location they may also have a major effect on the land use and amenity of their surroundings.

An overhead line and a substation that were both the subject of public inquiries are treated as case studies. The design of towers and insulators investigated to see whether engineering requirements are considered or modified to take account of aesthetics.

The screening of lines and substations by ground shaping and tree planting is frequently required by local Planning Authorities. The Board's attitude to this work, is evident from public inquiries and recent example of executed landscaping work. The thesis is illustrated with diagrams, maps and photographs.

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PREFACE

Man essentially lives in an environment of his own creation, exercising the power to enhance or destroy its aesthetic appeal. Many of our creative acts are necessary, and although they may show unattractive results, they are accepted because of their value to the community and the lack of any practical alternative. Other creations, equally necessary to sustain the development of a community, conflict more directly with aesthetic values and become the subject of controversy. Of nothing is this more true than the transmission of electricity.

This conflict is recognised in the statute creating the Central Electricity Generating Board, which is responsible for the generation and transmission of electricity, by requiring the Board "to develop and maintain an efficient co-ordinated and economical system of supply of electricity ....." whilst at the same time "to take into account any effect which their proposals would have on the natural beauty of the countryside .....".

Despite this thesis's occasional reference to electrical matters, no attempt is made to deal in detail with the technical aspects of the generating or transmission of electricity. This thesis involves a review of the development and organisation of the public service which is charged with the execution of these technical services, as necessary background to the primary object, to examine critically the effects that the transmission of electricity by overhead lines, underground cables and substations have on the use of land, and on amenity.

It only remains to add that this work has been compiled entirely from publicly available sources, and that the views and opinions expressed are entirely those of the author, and should not necessarily be taken as reflecting the official views of the industry, nor of any one part of it.

P A R T O N E THE DEVELOPMENT OF ELECTRICAL TRANSMISSION

CHAPTER ONE

Historical Review of the Electricity Supply Industry

1.1 Introduction

To understand fully the development of electrical transmission in this country it is necessary to have a knowledge of its origin, and the various stages of its subsequent growth. In tracing the development of an industry one may consider how it first emerged in the life of the community, and what were the principal attitudes of contemporary thought and practice which played a part in shaping it during the main formative periods. This is the approach that has been adopted in the writing of this chapter.

1.2 Early Days of the Industry

Faraday's fundamental discovery of electro-magnetic induction was made in 1831, but very little progress was made in methods of generating electricity for nearly 40 years. Instances of electric lighting were still largely of an experimental nature, and it was not until the development of the vacuum carbon filament lamp between 1875 and 1880 that there was any appreciable demand for an organised supply of electricity. Several private companies had the agreement of various local authorities to install an experimental lighting system, which helped to stimulate a general spread of interest in this new form of illumination (1).

The further development of electric lighting by private companies was to some extent frustrated by the limiting aspects of public administration. Gas and water undertakings were already well established with rights of public supply protected by statute, and similar protection was sought by electricity undertakings. By 1878 thirty-four Private Bills were introduced into Parliament with the object of seeking powers to supply electricity in various towns, and to break up streets to lay the necessary mains. In order to suggest some principles against which the House of Commons could consider all these Bills it appointed a Select Committee under the chairmanship of Sir Lyon Playfair. (2) This Committee reported in June 1879 and gave the opinion that legislation at that time would serve only to restrict the rapid development of the industry which was then becoming apparent. It recommended that local authorities' power to break up streets should be extended to the laying of electricity mains, but that the power should not be given to companies without local authority consent.

The first public supply of electricity in Britain was provided in 1881 at Godalming, Surrey. (3) It was installed and operated by Messrs. Siemens Bros. & Co., under a yearly contract with the Town Council for the lighting of the streets, and current was also made available for private consumers. Power was developed from a waterfall on the River Wey, and the cables were laid in the gutters along the streets, which were lit by both arc and incandescent lamps. The undertaking was an uprofitable one for the Company, because demand was insufficient and the supply was discontinued on 1st May, 1884.

During the time of this first unsuccessful attempt to provide a public supply of electricity, the recommendation of the Playfair Committee had become the Electric Lighting Act of 1882. This Act however subjected any private undertaking to a seven year's licence and also the threat that a local authority may purchase the undertaking operating in their area at the end of 21 years. These restrictions were sufficient to discourage the formation of electricity companies, and suggested that further amendments to the statute were necessary. These were subsequently incorporated in the Electric Lighting Act of 1888, which extended the tenure of a private electric undertaking from 21 to 42 years, but despite this the Act gave little encouragement to the formation of large companies. The use of electricity was confined almost entirely to lighting, and its development on a commercial scale was a speculative risk. For these and technical reasons, only small distribution undertakings were set up, each with its independent power station. The system continued to grow, by many small units in urban areas, but there was no attempt to bring about a uniformity of supply conditions, and there were prohibitions against the association and combination of statutory undertakings.

By the end of the century, advances in the techniques of generation and transmission, were changing the economic area of supply from under ten, to several hundreds of square miles. The development of the electric motor was greatly extending the uses of power for industrial and other purposes, and advanced the possibilities of large scale production of electricity. The advantages of co-operation and the formation of larger undertakings by amalgamation of smaller units gradually becoming realised.

The rest of this chapter describes the slow progress of the amalgamation of the original small undertakings into wider geographical units, and the later interconnection of their electrical distribution networks. The first conscious step in that direction was the appointment of the Cross Committee in 1898 (4). The Committee initiated compulsory powers of acquisition of sites for generating stations, and this was embodied after a significant delay in the Electric Lighting (Amendment) Act 1909.

The delay of ten years between the publishing of the Report in 1898 and the passing of the 1909 Act indicates the difficulties involved in trying to resolve the situation. It was recognised that the issues raised in the Power Company Bills subsequent to the Cross Report were such as to call for full and public legislation. The conflict between private and municipal undertakings mentioned above was so acute as to make Bills for major re-organisation very controversial and the Act of 1909 was a compromise measure.

1.3 Impetus of the First World War

The outbreak of the War and the subsequent increased demand for power exposed the weaknesses of the electricity supply industry. The increase in demand for electricity was so great that the full electrical load could be met only by the continued use of equipment that was already due for replacement. These conditions were aggravated by the increasing demands for coal, the supply of which was already insufficient for war requirements. These factors emphasized the inadequacy of electricity supply in relation to a greatly increased general demand. The need for economy in the use of coal, together with the security of supply to vital war industries that depended on a single source of electricity supply, showed that the interconnection of generating stations would be well worth while. At the instigation of the Board of Trade, (5) Linking up Committee, consisting of representatives of the authorised undertakers concerned, were set up in several districts to investigate what could be done in this direction by voluntary effort. There was some practical result, but it become evident that something more was necessary.

The clearest indication of the general possibilities was brought out in a series of three Government sponsored Committee Reports which appeared at the end of the war.

The first of these was the Haldane Report (6) followed immediately by the Parsons Report (7) which issued a memorandum setting out the position of the public supply of electricity:-

> "Sufficient time has elapsed and sufficient experience is available to show the defects of the original legislation. Experience has shown that the comparatively small areas of the companies and local authorities working under Provisional Orders are, in many cases, insufficient to enable advantage to be taken of modern improvements in plant". (8)

The most significant of these committees was appointed by the Board of Trade under the chairmanship of Sir Archibald Williamson. (9) The Report of this Committee, whose recommendations mark the genesis of re-organisation of the industry on a national basis included the statement,

> "that the parochial system of generation and distribution should give place to more economical methods involving wider areas of distribution".

The unanimous conclusion of its members was that one central authority, to regulate the generation and distribution of electricity, was required, and it was suggested that a body, to be known as the Electricity Commissioners, should be appointed for this purpose. The country was also to be divided into districts, in each of which a Board was to be established. This Board was to acquire all the generating stations in that district and also to be responsible for their operation. This was the first beginning of the system as we know it today and the inter-war period showed only a hesitant adoption of these principles.

Soon after the war ended the recommendations of the Williamson Committee were embodied in a Bill which was so amended in its passage through Parliament that the subsequent Electricity (Supply) Act 1919 did not fully reflect the Committees' proposals.

At about the same time another committee was appointed under the chairmanship of Sir Henry Birchenough. (10) The Committee agreed in the main with the Williamson Report, but the basic conclusion of the majority of the Committee was very far sighted, and if acted upon then, would have anticipated the Electricity Act of 1947 by twenty-eight years. This broad conclusion is quoted from their report: (11)

> "Electrical power should be generated and transmitted throughout the United Kingdom upon a single unified system, organised and conducted upon commercial lines, under State regulation and with such financial co-operation on the part of the State as may be found necessary in order to secure the speedy development of an effective system of electric supply throughout the Kingdom".

The proposals of the Birchenough Report were too ambitious for general acceptance at that time and were ignored.

The 1919 Act followed the main trend of previous legislation in that it was an enabling Act, but without powers to enforce reorganization on a national scale, relying on achieving in both voluntarily and through the duties of the Electricity Commissioners. These Commissioners were appointed for the purpose of 'promoting, regulating and supervising the supply of electricity' (12) In carrying out their responsibilities for improving the organization for the supply of electricity on a regional basis, the Commissioners delineated districts and investigated a number of regional schemes for centralising generation in a relatively small number of large generating stations to be owned by Joint Electricity Authorities.

Subsequently, five Joint Authorities were established, with powers to promote regional schemes.

There was no power to enforce local amalgamations, and the proposed transfer of stations and transmission lines from individual authorities to achieve economic schemes was in most instances frustrated by lack of agreement between undertakers. The Commissioners found themselves beset on all sides with difficulties, as their early annual reports record. (13) In their report for the year ending March 1924 the Commissioners summed it up in these words:-

> "It cannot be too strongly stated that united effort and a willingness to pool resources for the common good are essential to produce the larger results of cheapening the supply throughout electricity districts and bringing about a great extension of public supplies for all purposes. The powers of control vested in the Commissioners by the General Acts have enabled progress to be made in securing co-ordinated development during the past four years, but it has become apparent that a real organisation, which will adequately serve the requirements of the country, can only be achieved on the voluntary basis of the Acts of 1919 by a radical change in the attitude of authorised undertakers in general, and that, failing the early disappearance of the obstacles which have hitherto retarded progress, the whole position will call for review." (14)

The Government shared the belief in the necessity for compulsory powers by introducing a Bill in 1920 to cover the controversial clauses, but opposition by local authorities caused the Bill to be withdrawn. At the same time, there was a growing appreciation of the need for reorganisation of the industry on a bigger scale in the interests both of the consumer and of the industry. Consequently, when it became clear that there was no hope of widespread voluntary action, the political pressures for stronger measures of reform again began to be felt.

1.4 The Failure of Voluntary Co-ordination

A national system of trunk mains had been under consideration at the time of the Williamson Committee, (15) and had been officially supported by the Birchenough Committee's Report (16), but such a major development had been considered too revolutionary at that stage. In the early 1920's the concept of national control of generation and transmission was revived, although it was recognised that technical variations in systems in different parts of the country would make it both difficult and costly to achieve.

In parallel with the consideration being given to the future of electricity the problems of unemployment, particularly in relation to the coal industry, were still at a critical stage. The 1921 stoppage in the coal mines, and the possibility of continued political controversy surrounding the question of nationalization of the coal mines threatened serious consequences for the country as a whole. In an effort to resolve the difficulties arising from the interlinked questions of coal and electricity an unofficial committee was formed under the chairmanship of the Right Hon. David Lloyd George in March 1924, in an endeavour,

> "to find out what was really wrong, and to formulate proposals for reform which might be carried into effect by general consent, and with the minimum of controversy and delay".

The results of this inquiry were made known in a report on "Coal and Power". (17) The proposals included compulsory powers of acquisition, co-ordination and regulation to enable the Electricity Commissioners to grant to approved bodies the right of supplying power within substantial defined areas. The Lloyd George Committee's proposals formed the basis of the Government's policy, promising the introduction of a Bill to give these additional powers to the Electricity Commissioners.

To make any such scheme for an extensive generation construction and central transmission programme effective on the basis of the recommendations of the Lloyd George Committee, some control of construction was considered essential. This concept was further advocated by G.V. Twiss (18) in two articles in "The Electrician" which exercised a considerable influence on the development of this idea. This seemed to suggest a reorganisation on a national scale, calling for State sponsorship. The Conservative Government of 1925 accordingly appointed a committee (19) under the chairmanship of Lord Weir to:-

> "review the national problem of the supply of electrical energy and to present a report on the broad lines of policy which should be adopted to ensure its most efficient and effective development".

The Electricity Commission had been in existence for five years when the Weir Committee was appointed and the Committee confirmed the views of the earlier Williamson Committee, (20) that to produce effective results stronger powers were needed. They reiterated the view that after five years of voluntary co-ordination the industry was still not generating, transmitting or distributing electricity as cheaply as it might, nor was the country using electricity to anything like the same extent as other comparable countries. They drew attention to the lack of organisation in the encouragement of the use of electricity, and compared the situation in this country very unfavourably with some other countries. The Committee also recommended the establishment of a system of main transmission lines, designated the "grid-iron", for the purpose of interconnecting the principal generating stations throughout the country in which the generation of all the supplies required by authorised undertakers was to be concentrated. It also recommended the setting up of a Central Electricity Generating Board, which was to be responsible both for the erection of the "grid" and for the operation of the stations "selected" to feed it. It also proposed that the frequency of electricity should be standardised throughout the country.

The Weir Committee Report was not published until 1926 at the same time as a Bill based on its recommendations was introduced by the Government. There was a good deal of opposition to the Bill in its various stages, particularly from those who would be directly affected by the compulsory measures proposed. Political pressure was also directed to reducing the power of control proposed for the Electricity Commissioners. With some amendments to meet the more severe of these objections the Bill was passed in November of the same year to become the Electricity (Supply) Act 1926. (21)

The Act's most outstanding feature was the creation of the Central Electricity Board, and in thus providing for the central co-ordination of generation and main transmission of electricity it succeeded in meeting the technical demands of the industry as no previous legislation had done.

1.5 Beginnings of a National System

The establishment of the Central Electricity Board as a public corporation was a fundamental step both in re-organisation of the supply industry, and also in the combination of national planning with commercial operation and administration. The appointments made by the Board of Trade showed that half of the members had electrical engineering experience, which recognised the need for specialist experience for implementing the proposed scheme of grid transmission, that the Act now made possible. The general functions of the Electricity Commissioners in relation to the Central Electricity Board was to submit to the Board for their approval schemes for new generating stations and transmission lines. (22)

The Weir Committee proposals, and the 1926 Act were primarily directed towards reducing the cost of electricity and ensuring that it would be available over wide areas of the country. The Act also included some minor provisions towards easing the problems of the distribution undertakings, but in avoiding major interference with their existing rights the opportunity of simplifying and co-ordinating the distribution systems was missed. That the existing structure was in need of re-organisation was widely recognised, and various aspects which gave cause for concern had been subject of comment by the Electricity Commissioners from time to time in their annual reports. (23) As the grid system began to take shape and to show the anticipated savings in generation and transmission costs, the need for a parallel re-organisation for electrical distribution became even more apparent. (24) As part of the Government's efforts to stimulate economic development at a time of industrial depression a series of conferences were held with representatives of the Electricity Supply Associations and Undertakings, (25) to encourage further the voluntary amalgamations of the smaller undertakings. By 1935 the demand for action was widespread, but of many divergent views. In response to this situation the Minister of Transport, who had inherited powers previously exercised by the Board of Trade in respect of the electricity industry appointed a Committee of three, under the chairmanship of Sir Harry McGowan. (26)

This Committee drew attention to the large number of 635 local electricity undertakings, the variation in their size, and the differences in the type and pressure of current supplied. The Committee proposed the establishment of temporary District Commissioners for the preparation of schemes of re-organisation, and suggested that the larger and more efficient undertakings, whether municipal or company, should take other supply undertakings in their area. One of the criticisms of the report was that it over-emphasised the value of size in a distribution undertaking.

There was no reason to suppose that a small undertaking was necessarily less efficient than a large one.

In March 1937 the Government announced that they had decided to adopt in principle, subject to modifications in detail, the recommendations of the McGowan Report (27). This report was shortly followed by the confidential issue of a White Paper (28) which contained tentative proposals for the amalgamation of all electricity supply undertakings into seventy six main groups. The implementation of the Government proposals was delayed in the immediate pre-war period, and in November 1938 the Prime Minister announced that there was no prospect that legislation to deal with this matter would be proposed during the life of that Parliament.

1.6 Nationalization

During the early years of the war little public attention was given to questions of reorganisation of the electricity supply industry, but in 1943 a number of suggestions (29) were put forward by individual undertakings, trade associations, and staff associations. Some of these were in response to a request by the Ministry of Fuel and Power to the industry to submit to him their proposals for post war reorganisation.

Early in the war a Joint Committee of Electricity Supply Undertakings (30) was set up representing both company and municipal undertakings. The immediate object was to enable undertakings to keep in touch with one another in dealing with common problems resulting from the war. When the Minister of Fuel and Power asked for plans for the post war reorganisation of the industry, the Joint Committee attempted to draw up a scheme.

In November 1943, the Committee announced that irreconcilable views on ownership and control had made it impossible to reach agreement.

Three months later a compromise was submitted which accepted the general principle that ownership and organisation of the existing undertakings should not be subjected to drastic alteration unless it could be proved that consumers would obtain a substantial and permanent benefit. There was general agreement throughout the industry on the principal technical objectives to be achieved, which were the grouping of areas of supply in order to ensure the maximum diversity of load and greater uniformity of systems of supply, voltages and tariffs. On the other hand there was strong disagreement amongst the Committee as to how these objectives should be achieved.

During the remaining years of the war there were no further legislative developments concerning the supply industry but the problem of its organisation continued to receive attention in relation to the economic and social planning which was being undertaken by the Government. After the General Election of 1945 there was a further examination of the problem, which resulted in the introduction of the Electricity Bill in the House of Commons on the 20th December, 1946.

In June 1947 Mr. Shinwell the Minister of Fuel and Power in anticipation of the passing of the Act appointed an 'Organising Committee'.(31) The primary consideration of this Committee was to set up a skeleton organisation on which the new Authority could build, and to prepare reports on the problems of the transfer of undertakings, for consideration by the Authority and Area Boards as soon as they were appointed. Meanwhile the Bill was proceeding through both Houses of Parliament and was the subject of much disagreement and political controversy, as had been the case with earlier legislation. While all sections of the industry agreed on the need for more flexibility to allow further electrical improvements, and on the necessity for some form of grouping of undertakings, there were many different ideas as to how this should be undertaken. The Act which received the Royal Assent on 13th August, 1947 was substantially the same as the Bill in all its essential features, but it had undergone considerable redrafting in detail.

The Electricity Act 1947 established a Central Authority named the British Electricity Authority as the national organisation responsible for the generation of electricity, while fourteen Area Boards (32) were entrusted with the distribution of electricity in their respective regions (33) The task of the Central Authority was "to develop and maintain an efficient, co-ordinated, and economical system of supply". (34) For that purpose it was required to generate electricity and provide supplies in bulk to the Area Boards for them to distribute, to co-ordinate distribution by the Area Boards; and to exercise a general control over them in regard to policy and finance. The Area Boards were required to purchase supplies of electricity from the B.E.A., and to plan and carry out in an efficient and economical manner the distribution of those supplies to individual consumers. The B.E.A. and the Area Boards were faced with the task of making a unified national electricity system out of 560 separate supply undertakings. About a third of the industry was previously owned by commercial companies and the remaining two thirds by municipal corporations. The organisation set up in 1947 gradually achieved this amalgamation, and also initiated a programme of building new power stations and transmission lines.

On the 1st April, 1955, under the Electricity Re-organisation (Scotland) Act 1954 the B.E.A.'s undertaking in Scotland were vested in a new public authority called the South of Scotland Electricity Board and the name of the British Electricity Authority was changed to Central Electricity Authority although its other functions remained unaffected. This new authority the C.E.A. survived less than three years.

1.7 Present Structure of the Industry

The legal authority and division of responsibility between the C.E.A. and the Area Boards appeared to be reasonably well balanced. However, the Herbert Committee (35) which was appointed in 1954 to inquire into the working of the electricity supply industry, criticized the organisation on two main grounds. Firstly, that it was over-centralized, and secondly, that it was a mistake to entrust the C.E.A. with both executive and supervisory functions. They accepted the principle that generation should be the duty of the C.E.A., and that distribution should be carried out by the Area Boards. One of the unsatisfactory features of the situation was that the planning, preparation, and construction of a power station took as long as eight years, so that by the time it came into commission it was already technically obsolete. This was in part due to excessive supervision by Headquarters, and the need for Divisional Controllers to obtain Headquarters approval at too many stages of each project (36).

The main recommendation of the Herbert Report was that a Central Electricity Generating Board should be set up to take over executive responsibility for the design, construction, and operation of power stations, the grid, and the projected super-grid. It would plan the general development of electricity supply, and the main transmission system. It would also be responsible for the siting, design and possibly the construction of nuclear power stations, as well as for research and development; staff and financial policy,and the control of electrical transmission over the whole system. (37)

The recommendations of the Herbert Committee formed the basis of a Government White Paper (38). The Government however did not accept the Committee's view of the function of the Central Electricity Authority, but decided to establish in its place an Electricity Council. This was intended to be a forum in which the generating and distributing sides of the industry could meet to discuss and settle their common problems under independent guidance (39). These amended proposals subsequently became the Electricity Act 1957 which required the new authorities to assume their duties on the 1st January, 1958. This Act still remains the principal Act giving statutory authority for the present three tier organisation of the Industry. There is however a study group set up by the Minister of Power (40) to examine whether any changes in the organisation and structure of the industry needs to be made. It is thought that the group will recommend that the division between generation by the C.E.G.B. and distribution of electricity by the Area Board, should be ended. It has been widely felt that the existing structure gives a disproportionate influence to the C.E.G.B. and that any changes are likely to strengthen the position of the Electricity Council (41) The report is expected to be made public in about March, 1969. (42)

This review of the development of the public use of electricity over a period of 87 years, has of necessity been brief, but in essence it is the story of the gradual change from local private undertakers to a national publicly owned industry. The next two chapters will consider why the interconnection of power stations has become necessary, and the rate at which this interconnection by the grid and supergrid was constructed, with its inevitable increasing effect on land use and amenity.

CHAPTER ONE

References

1. A demonstration of a lighting system inside and outside Billingsgate Fish Market was made in November, 1878 followed soon afterwards by Lighting of the Thames Embankment and Holborn Viaduct by the Société Générale d'Electricété.

2. House of Commons Select Committee. Chairman, Sir Lyon Playfair. Reported June, 1879. H.M.S.O.

3. Early Days of the Power Station Industry by R.H. Parsons. Cambridge U.P. 1940 p. 12.

4. Report from Joint Select Committee of the House of Lords and House of Commons on Electrical Energy, Chairman Viscount Cross. H.M.S.O. 1898.

5. Circular issued by the Board of Trade 1916 required interconnection of Power Stations. Parsons Report op. cit. ref. 7 para. 22.

6. Interim Report on Electric Power Supply in Great Britain, by the Coal Conservation Sub Committee of the Reconstruction Committee, Chairman Viscount Haldane. Report dated 17th April, 1917. Cmd 8880 pub. H.M.S.O. 1918. Main recommendation: para. 48 (1) that generation and transmission should be reorganised on a regional basis.

7. Report of the Departmental Committee appointed by the Board of Trade to consider the position of the Electrical Trades after the War. Report dated 18th April, 1917. Cmd. 9072 H.M.S.O. 1918. The 'Parsons' Report.

8. Parsons report. op. cit. para. 23.

9. Report of the Committee appointed by the Board of Trade to consider the question of Electric Power Supply. Chairman Sir Archibald Williamson (later became Lord Forres) Cmd. 9062 H.M.S.O. dated 29th April, 1918 summary of recommendations p.17.

10. Report of the Committee of Chairmen of the Ministry of Reconstruction Advisory Council, on Electric Power Supply. Report dated 18th October, 1918 Cmd. 93 H.M.S.O. 1919. The 'Birchenough' Report.

11. Birchenough Report Op. cit p.6. The Committee also recommend "that the Electricity Board should be left absolutely free to consider and deal with the whole problem of electrical supply - including distribution as well as generation and main line transmission". The Report also included three dissentient minutes, two which opposed the recommendation of State control, and the third which disapproved the use of compulsory purchase of existing public undetakings.

12. Electricity (Supply) Act 1919 section 1 (1)

13. The Electricity Commissioners Annual Reports. H.M.S.O. 1st Report 1921 p.9 para. 11. 2nd Report 1922 p.6. para. 5. 5th Report 1925 p.9 para. 18.

14. The Electricity Commissioners Annual Report H.M.S.O. 4th Report 1924 p.10 para 18. 28 - 49.

15. Cmd 9062 Op-cit.

16. Cmd 93 Op-cit.

17. Coal and Power. The Report of an Enquiry presided over by The Right Hon. D. Lloyd George O.M., M.P. pub. Hodder & Stoughton London, undated. but c. July 1924. vide p.111 - 115 for main proposals.

18. Two Articles by Mr. George V. Twiss. The Electrician 23rd January, 1925. p.85, 88 - 90. and 30th January, 1925 p.111, 112, 116 - 118. He proposed, inter alia, a national scheme of transmission lines.

19. Report of the Committee Appointed to Review the National Problem of the Supply of Electrical Energy. Chairman the Right Hon. Lord Weir of Eastwood. Report dated 14th May, 1925. H.M.S.O. 1926.

20. Weir Report Op-cit. para. 7.

21. The Bill was debated in Standing Committee for 27 days and underwent considerable amendment. The Bill as amended was passed by the Standing Committee on 22nd July, 1926. The Bill, after further amendment during the Commons Report Stage, was read the Third time and passed on 12th November, 1926.

22. Electricity (Supply) Act 1926 Section 4 (1) (b) "Providing for interconnection, by means of main transmission lines to be constructed or acquired by the Board, of selected stations with one another and with the systems of authorised undertakers,...."

23. The Electricity Commissioners - 7th Annual Report 1927 p.11 para. 34.

24. Report of Proceedings of Conference on Electricity Supply in Rural Areas. Electricity Commission H.M.S.O. 1928. In the early part of 1927, the Commissioners decided to undertake a general review of the question of rural electrification in Great Britain. This matter had come into special prominence since the passing of the 1926 Act owing to the increased facilities for transmitting supplies over wide areas that could result from the carrying out of regional schemes by the Central Electricity Board.

25. Statement by the Minister of Transport the Right Hon. Herbert Morrison M.P. at Glasgow 19.1.31 Manchester 20.1.31. London 23.1.31, Leeds 26.1.31, and Bristol 10.4.31. Electricity Commission. H.M.S.O. 1931.

26. Report of the Committee on Electricity Distribution. Ministry of Transport. Chairman Sir Harry McGowan. Appointed in July 1935 and reported on 8th May, 1936. H.M.S.O.

27. Statement by the Minister of Transport in House of Commons on 3rd March, 1937.

28. Confidential White Paper on Electricity Distribution by the Ministry of Transport April 5th 1937. Not made public until June 8th, 1937. H.M.S.O.

29. Report of the London and Home Counties Joint Electricity Authority on the Reorganisation and Development of Electricity Supply Services and outline of Scheme for the London and Home Counties Electricity District. Dated 4th March, 1943. Proposals of the Conference of Joint Electricity Authorities and Joint Boards April, 1943. Schemes prepared by the Electric Power Engineers' Association, August 1943; and the Incorporated Association of Electric Power Companies, November 1943. A Report, Electricity Supply, Distribution, and Installation by the Post-War Planning Committee of the Institution of Electrical Engineers published by the Institution January, 1944. Main recommendation p.24 was the urgent need to standardize voltage.

30. This Committee was set up in December 1939 representative of the Incorporated Association of Electric Power Companies, the Provincial Electric Supply Association, the London Electric Supply Association and the Conference of Joint Electricity Authorities and Joint Boards.

31. The Chairman of this Committee, Lord Citrine subsequently became Chairman of the new Central Authority.

32. Fourteen Area Boards were later reduced to twelve when two independent Scottish Electricity Boards were set up following the recommendations of the Herbert Report. . Cmd 9672 para 114.

33. Vesting day was 1st April, 1948 when the B.E.A. and Area Boards assumed their statutory duties.

34. The Electricity Act 1947 Section 1 (1)

35. Report of the Committee of Inquiry into the Electricity Supply Industry. Chairman Sir Edwin Herbert. Appointed 9th July, 1954. Cmd 9672. H.M.S.O. January 1956.

36. Herbert Report Op-cit. para. 257

37. Herbert Report Op-cit. para. 248 to 252

38. Proposals for the Re-organisation of the Electricity Supply Industry. White Paper Cmd. 27. H.M.S.O. 1956.

39. Cmd. 27 Op-cit. para. 7.

40. Hansard. House of Commons 21. 3.68.

41. Financial Times 22. 1.69.

42. Since writing this chapter the Minister of Power, Mr. Roy Mason has made a statement in the House of Commons on the re-organisation of the electricity supply industry in England and Wales. The Electricity Council is to be re-named the Electricity Authority with new powers to plan and control the policy of the industry as a whole. The C.E.G.B. and area boards will remain as at present but will operate within the framework of a broad policy determined by the Electricity Authority. Hansard 18.7.69 Vol. 787 col. 1091. A Bill to give effect to these proposals is programmed for the present session of Parliament.

CHAPTER TWO

The Development of the Grid and Supergrid Transmission System

2.1 Introduction

The previous chapter traced the course of the electricity supply industry from its beginning to the present day, and formed a somewhat extended introduction to this and the next chapter. This brief history was principally concerned with the technical and political pressures that brought about organisational changes in the industry and this chapter will follow a similar path in tracing the development of the transmission system. It will deal with the specific reasons that brought about the need for a transmission system, the factors that influenced it, and the rate of its construction.

2.2 The Inception of a National Transmission System

The history of the industry up to the early 1920's has shown that in spite of the clear recommendations in the reports of various committees set up to examine the industry, legislation in itself was not solely responsible for the unsatisfactory position that had developed. Technical advances in transmission had by then made it possible to give an economic supply over considerable distances. The 1919 Act, even though it was a rushed and compromise measure, removed the final legislative barriers against co-operative action.

A national system of trunk mains had been under consideration in 1918 at the time of the Williamson Committee (1), and the following year had been officially supported by the Birchenough Committee's Report (2), but the industry at that time had considered such a major development as being too revolutionary.

In 1925 G.V. Twiss revised interest in this idea of a national grid in two articles he wrote which were published in 'The Electrician' (3). He developed his idea that on the grounds of economy an interconnected national scheme of primary transmission lines should be superimposed on the existing wholesale distribution networks, requiring the setting up of a new organisation to provide and operate the system.

The ideas put forward by Twiss were quickly and widely appreciated, and the immediate result of this renewed interest provided the impetus for the appointment of the Weir Committee (4) to review the national problem of the supply of electrical energy, and to report on the policy that should be adopted to ensure its most efficient and effective development. The Committee advocated a policy of concentration, and recommended the establishment of a national grid system of main transmission lines for the purpose of interconnecting the systems of all the public supply authorities in the country, and enabling them to give supply on a wholesale basis of electricity produced at the most efficient stations. It also recommended that standardisation of frequency in all the alternating current systems in the country should be undertaken "as part of a comprehensive scheme for improving our existing electricity system". The Committee further recommended the setting up of an executive body - the Central Electricity Board - which would be responsible for the erection and operation of the grid, and which should direct the operation of the stations "selected" to feed it. The Committee's recommendations, with certain modifications, were given effect in the Electricity (Supply) Act, 1926.

Under this Act it fell to the Electricity Commissioners, who had been set up under the Electricity (Supply) Act, 1919, to take the initial step in inaugurating the grid scheme. Accordingly, they prepared a series of regional schemes, determining which of the existing stations should be "selected" stations, and also a layout of the grid lines and transforming stations to interconnect them with one another and with the systems of other authorised undertakers.

The projected layout of the Grid was given in Sir Archibald Page's 1927 Presidential Address to the Institution of Electrical Engineers (5) and a general scheme for the main grid system was prepared and published in the first Annual Report of the Central Electricity Board (6). They drew attention to the fundamental difference between the main transmission systems constructed on the Continent and in the United States, as compared with that being planned for Great Britain. They pointed out that abroad the main problem lay in transmitting electricity in bulk from the generating stations, established near the source of power, to the distribution areas; the systems were, therefore mainly for long distance transmission in one direction only. In this Country the need was for interconnection of stations and areas to secure the most efficient and most economical use of production resources. The country was divided into ten regional areas and the individual schemes, as they were developed, were designed to interconnect to form the full national plan which was designed to meet the estimated peak loads on any part of the system with the largest generator and the largest transformer out of service. Whilst construction could be undertaken only in stages on the basis of regional schemes, there was a general appreciation that the transmission system and construction planning of the grid must be envisaged as a whole.

The voltage chosen for the Grid system authorised by the 1926 Act was 132,000, as the most economical for the purpose of inter-connection. The atmospheric pollution in many industrial areas in Great Britain meant that the Board had to take care in the design of insulators to avoid flashing over caused by deposits from the air. The voltage of 132,000 was, in 1926, also thought to be the highest practical figure from this point of view. It is not intended to go into the technical problems involved in building this countryside system, but one of the biggest problems was to achieve a standardization of supply and voltage (7).

2.3 The Development of the Grid

The Central Electricity Board had prepared a transmission programme for the construction of approximately 2,600 miles of 132 kV overhead transmission lines, and 31 miles of 132 kV cables, which was to be completed in ten years. This programme required the erection of over 28,000 steel lattice towers, and the installation of 273 transformers and switching stations, at a total cost of £26,700,000.

Diagram 1 summarises the progress of Grid planning and construction from the passing of the 1926 Act to full operation.

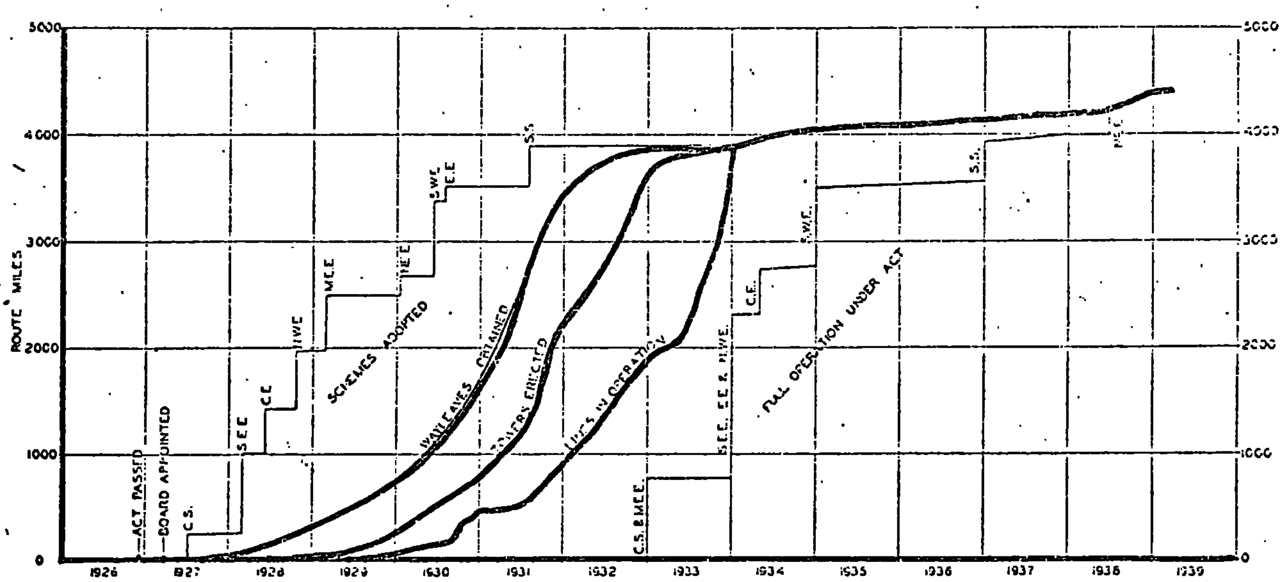


Diagram 1. Progress of 132 kV Grid Construction. (8)

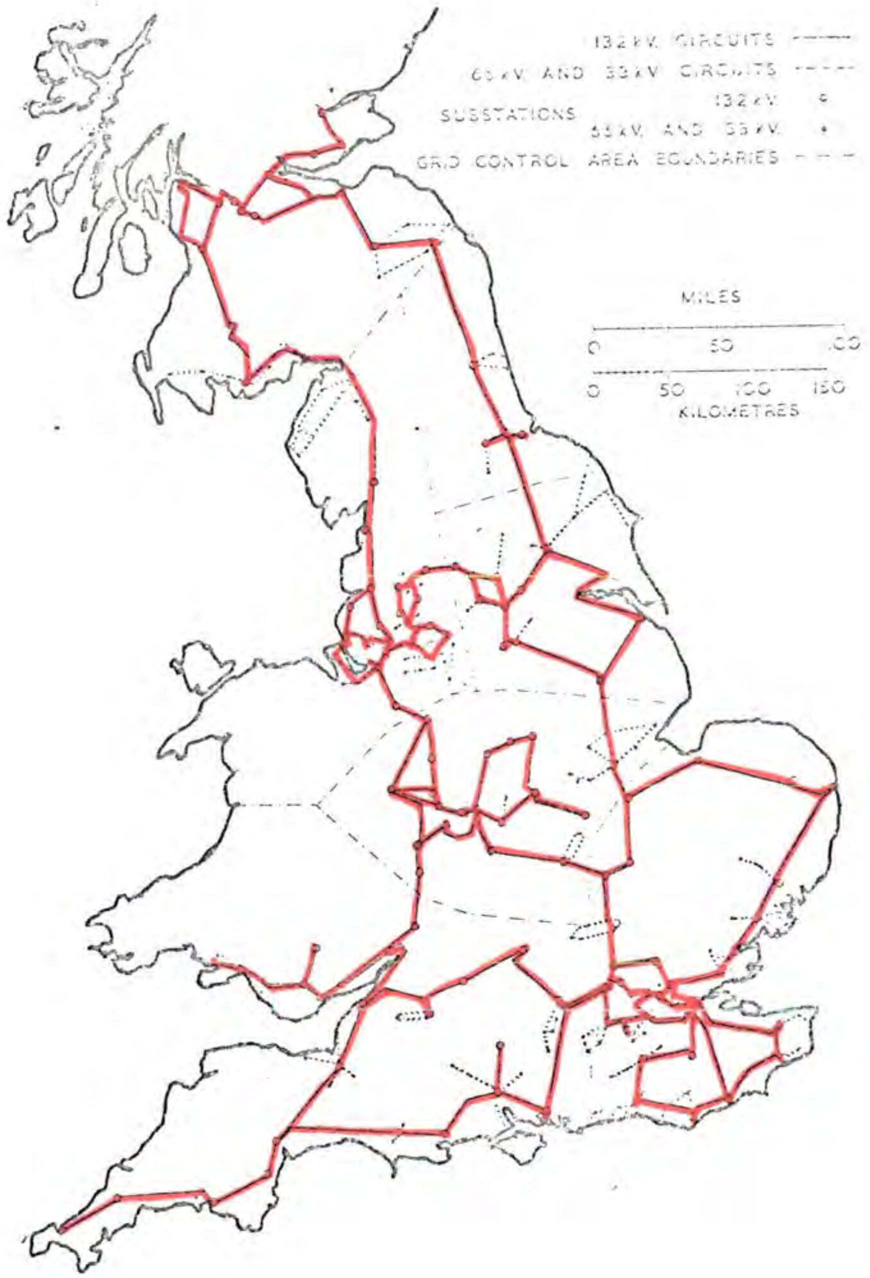
Progress was slow during the first years, only 58 miles of line having been erected up to the end of 1929. This is explained largely because of the preliminary and experimental nature of the work. The two succeeding years saw some improvement in this rate of construction and during 1931 and 1932 approximately 1,300 miles of lines were brought into service. The Board completed the original programme by 1933, in about half the time allowed, the last tower of the initial scheme being erected on September 5th, 1933 (9). By the end of 1935 when all areas were interconnected a total of 2,880 miles of line were in operation (10). From 1935 to 1937 further minor extensions were made, but during 1938 and 1939 with the prospect of war, the rate of construction once again increased.

Map No. 1 shows coloured in red the grid system in 1938, built at a total cost of approximately £30,000,000 (12) and over the period 1926 to 1938 the total costs of transmission came to nearly £135,000,000 (13).

2.4 The Grid System Between 1939 and 1945

At the end of 1939 the Grid comprised 4,430 miles of transmission lines, 3,039 miles of which operated at 132 kV and the remainder at 66 kV and lower voltages (14).

During the war only relatively small extensions of the Grid were made for normal purposes but considerable reinforcements were made for specific war purposes. This is shown in Table No. 1 which shows the increase in mileage of 132 kV transmission lines during the war years 1940 - 44 inclusive.



Map No. 1 - 132 kV Grid in 1938

Year	Grid Extensions	War Time Grid Reinforcements	Lines for War Factories
1940	71	NIL	NIL
1941	2	155	40
1942	34	208	31
1943	3	NIL	NIL
1944	12	NIL	NIL
Total	122	363	71

Table No. 1. Increase in Mileage of 132 kV Transmission Lines from 1940 to 1944 (15)

Map No. 2 indicates in red where the 363 miles of Grid reinforcements for war purposes were built. In this map and the succeeding ones which mention individual substations, there are slight variations in the names given to the substations in the original maps.

The greatest significance of the second world war in the development of the grid was that the system was originally designed as interconnecting and operating in large self-contained areas, but from the beginning of the war it was considerably reinforced as a transmitting system operating as a single national unit. A National Control organisation was set up to provide the necessary co-ordination.

There was an initial drop in the demand for electricity in South East England with its large pre-war non industrial load, which consequently released more generating capacity to be made available in other areas. The Grid was therefore extended to enable the transmission of this reserve to other parts of the Country. A study of the power flow

Map No. 2 - 132 kV Grid in 1945 showing Wartime Reinforcements diagrams for the war years shows that a lot of this surplus power in the South East was transmitted to the war factories in the South West area and in South Wales.

Experience during the war years 1939 to 1945, when the electricity industry was primarily concerned with meeting the demands of industry and war production, proved the value of the integration of the supply system through the national grid. The priority given to munitions production during those years meant an almost complete standstill for the construction of new generating stations. To meet the growing demand for electricity the fullest use had to be made of existing plant, with new construction restricted to the minimum essential for war needs. The existence of the grid enabled the electricity supply industry to achieve its maximum output. On the other hand a direct result of the grid meant that a smaller margin of surplus generating plant was available to meet the demands, which soon exceeded the small increase in generating capacity.

Similarly the construction of new transmission lines was restricted to that necessary to enable areas in which a rapid expansion of demand had occurred to obtain assistance from adjoining areas where the war had brough about a decline. However, the construction of the grid, and the experience gained in operating the system during the war, showed that the local availability of electric power supplies was no longer the primary consideration in the location of new industries.

2.5 The Superimposition of the 275 kV Grid

In the early post war period of generating plant shortage, arising from war time and post war building restrictions, the Grid was called on to meet increasing transfers of power throughout the country so that load shedding could be kept to a minimum. With a view to meeting these additional requirements the Central Electricity Board in 1942 set up a Committee to investigate the best method of extending the 132 kV grid system. This seemed to be the most natural course to take as it would not introduce any major changes in overhead line or plant design. The Board however were obliged to look further ahead in its planning, because the forecasts of the future demand for electricity quickly made it apparent that the structure of the existing 132 kV grid system would soon be inadequate. The multiplicity of lines that would be required to meet future requirements would present serious operating and maintenance problems. Probably an equal reason for the decision to operate a higher voltage was the increasing difficulty of obtaining consents and wayleaves for overhead lines, and the considerable amenity impact such a network would have on the country. Five lines of 132 kV towers would have been necessary to carry the same power as one line operating at 275 kV and this aspect was probably a major consideration in the recommendation to adopt a higher voltage.

The Committee concluded that in order effectively to meet the load to be expected by about 1960, and to retain the advantages of a single national system of main transmission, it would be necessary for technical reasons to divide the 132,000 volt system into about ten sections and to interconnect them through a 264,000 volt system. Although such a system was desirable to provide security, it was doubtful at that time whether its cost could be justified on economic grounds.

The Committee was reconstituted at the end of 1945 and continued investigations in 1946 and 1947. In an interim report issued in November, 1946, they concluded that as a result of recent developments in switchgear manufacture, which made available 132,000 volt switchgear of greatly increased "rupturing capacity" it would be possible to meet interconnection requirements up to 1960 by development at 132,000 volts. On the question of long-distance transmission, the Committee were unable to reach a decision because of uncertainty as to future policy on coal prices, the development of coalfields, and rail transport costs.

Investigations were continued after nationalisation by an inter-departmental Committee of the newly constituted British Electricity Authority. After studying the supply problem for the next twenty years they recommended that a substantial increase in the capacity of inter-connection between different parts of the country was necessary to conserve capital expenditure in generation and transmission, and the best way to provide this capacity was by means of a higher-voltage system, additional to the existing 132,000 volt system. They considered that such a system, would be no more costly than development at 132,000 volts to meet the increasing interconnection requirements, and would have the added advantage that it would make possible the long-distance transmission of substantial blocks of power.

The voltage to be adopted for the higher voltage system presented certain problems in view of the effect of atmospheric pollution on the insulators and conductors of transmission lines. An obvious choice might have been a simple doubling from 132,000 volts to 264,000 volts, but in the interests of international standardization the Authority decided to choose the next nearest International Electro-Technical Commission voltage level of 275 - 300 kV. To prove that this pressure could be successfully employed in Great Britain a length of overhead line operating at this voltage was erected near the Authority's high voltage testing station at Leatherhead in Surrey.

The Authority therefore decided:-

"1. that a 275,000 volt system, capable of meeting probable requirements for at least the next twenty years, should be planned forthwith, and that consideration should be given to designing the towers for certain sections of this system for later operation at a still higher voltage;

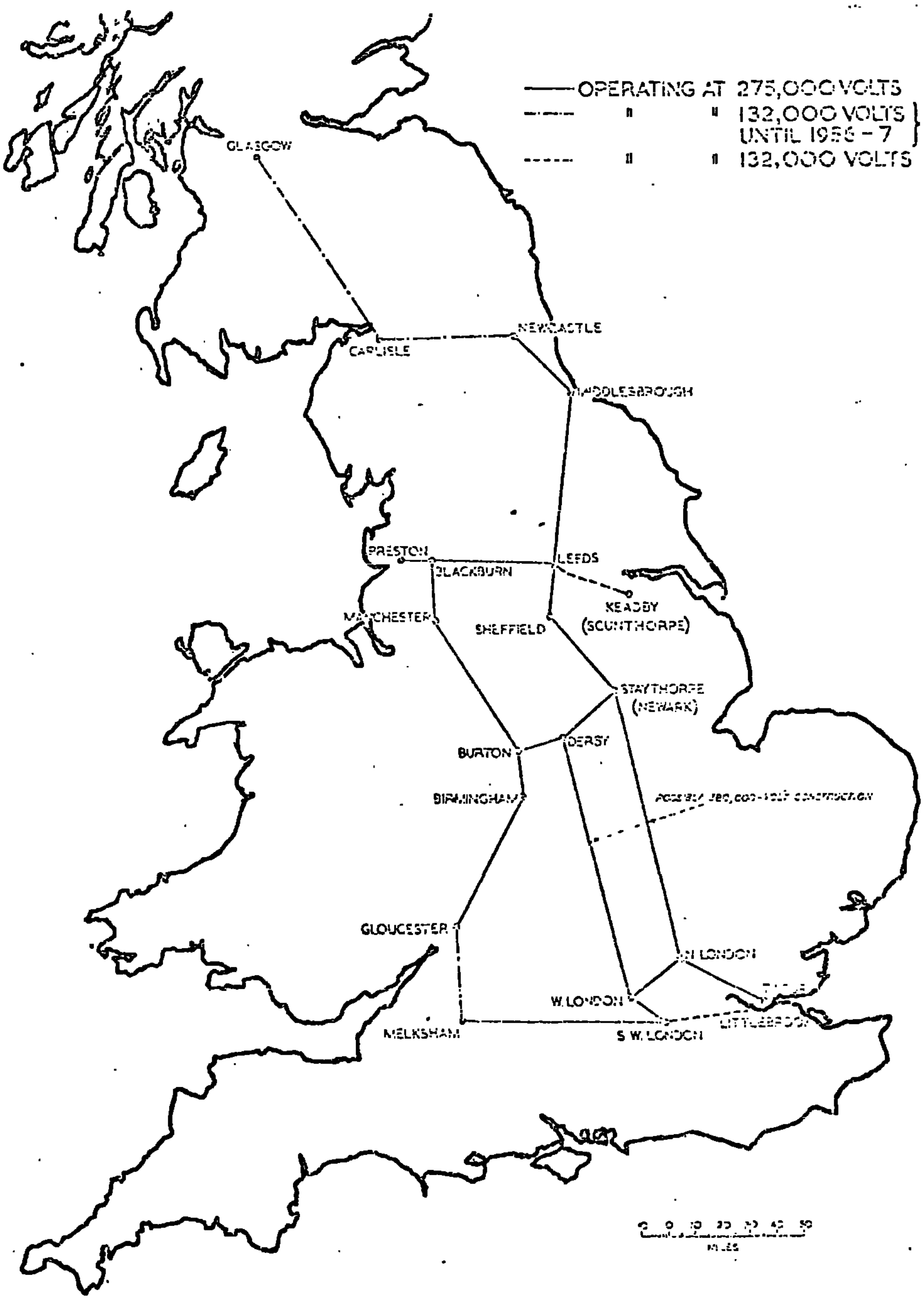
2. that a detailed programme should be prepared for the construction of those stages of the system necessary to meet requirements up to 1960; and

3. that those immediate reinforcements of the existing 132,000 volt system which would subsequently form part of the 275,000 volt system should be designed and constructed for the higher voltage." (17)

In 1950, shortly after this decision to proceed, the Authority approved in outline the proposed development of the 275 kV system up to 1960. This is shown diagrammatically on Map No. 3. (18) They also approved £7,750,000 for the first stage of construction (19) followed by £12m the following year (20) and a further £14.5m in 1952 (21).

The new grid system to be superimposed on the 132 kV system, required the construction of 1,150 route miles of overhead line operating at 275 kV, with 22 switching and transforming points. All but a single short section of the new Supergrid would comprise double circuit lines, joining the Midlands to London and South-West England, and there was also proposed to be a connection to the North-East Coast and onwards to Scotland.

The first section of the 275 kV supergrid was the 41 miles between Staythorpe (Newark) and West Melton, Sheffield completed in 1951,



Map No. 3 - 275 kV Supergrid, as proposed in 1951 for Development to 1960

Diagram No. 2 shows the rapid development of the system over the twelve years from 1953 to 1965 reaching a maximum of over 2,000 route miles, and thereafter showing a slight reduction in the total mileage as the circuits are uprated to 400 kV. Map No. 4 shows the 275 kV Supergrid as built in 1960 which is interesting to compare with Map No. 3 which indicates what the Board in 1951 planned for 1960. The additional electrical connections are marked in red, and it will be quickly appreciated that the Board's 10 year construction programme was implemented substantially as originally planned.

After 1965 the mileage of 275 kV line was reduced as the towers were reinsulated and restrung for 400 kV working, when the original purpose of the 275 kV network was superseded by the larger carrying capacity of the 400 kV Supergrid. However, 275 kV lines are still being built, as the 275 kV rings around the conurbations of London, Birmingham, Liverpool, and Manchester are being completed. Map No. 6 indicates in red the 275 kV circuits at the time of writing, and by comparison with the 275 kV lines operating in 1960, (Map No. 4) it will be seen that very little of the original 275 kV Supergrid remains and its present operations are restricted exclusively to the function of a high voltage distribution system around the major conurbations.

2.6 The 400 kV Network

The 275 kV Transmission System at the time of its inception in 1950, was designed to form part of a national supply system with an anticipated total demand of 30,000 MW's by 1970. The rapid increase in electrical demand led the Generating Board to consider whether the present system should be further reinforced and extended or whether a higher voltage should be introduced. In 1959 the Board decided that it was necessary to move to a higher voltage, both to ensure the stability of the system under increased demand, and to avoid the installation of many more 275 kV

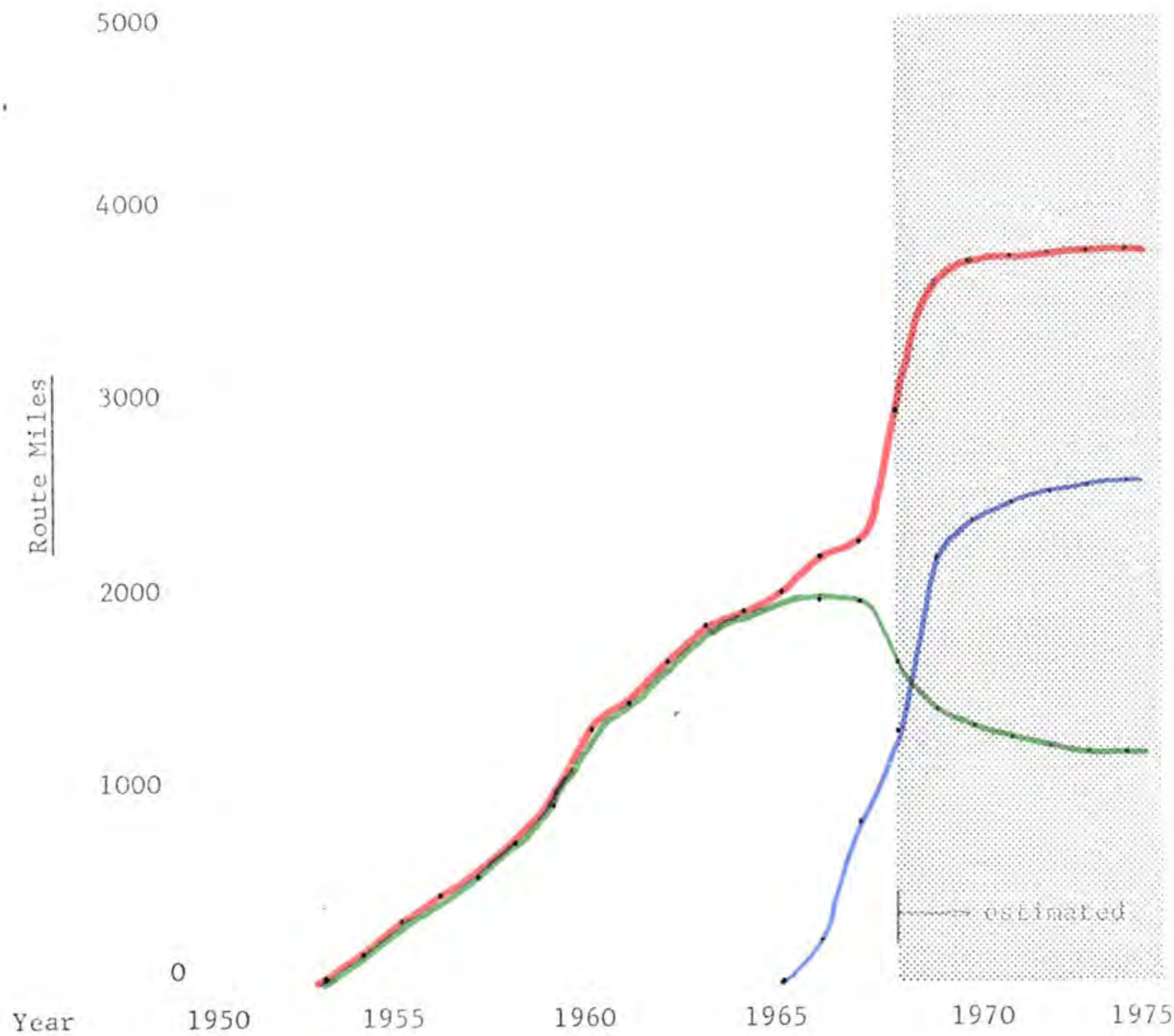


Diagram No. 2 - Comparison of rate of construction of the 275 kV and 400 kV Supergrid, plotted from data given in Appendix A.

275 kV shown   400 kV shown   Total shown

Map No. 4 - 275 kV Supergrid in 1960. Lines in red indicate the additional circuits to those proposed in 1951.

lines to the detriment of visual amenity. At this time several other countries had developed transmission lines of a higher voltage. Russia was using 500 kV lines, Canada and the United States were using 380 kV lines, and the adoption of either voltage would have given a sufficient margin for future expansion.

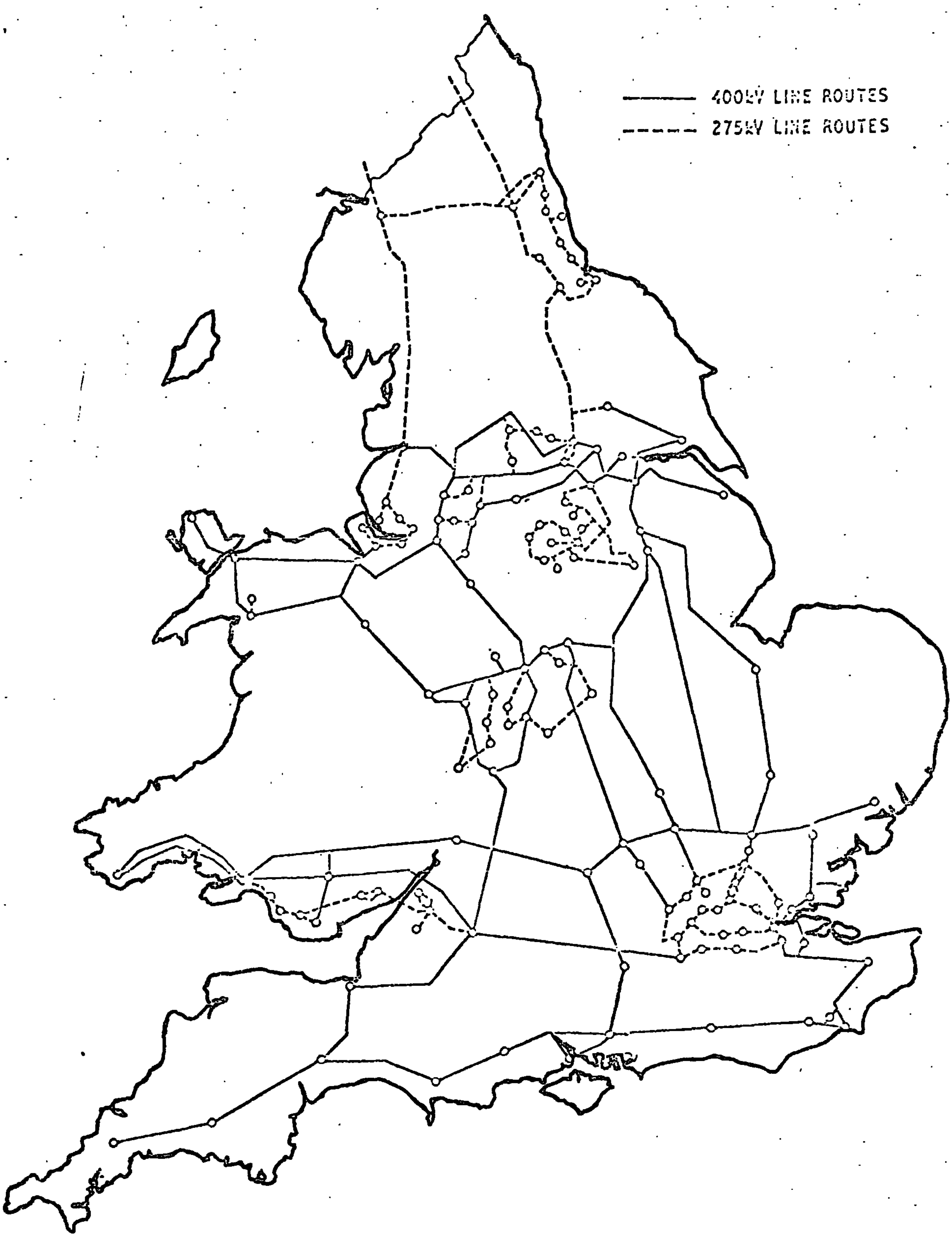
The Board carried out a two year study of the alternatives, which was completed in September 1960 (26). This was described in a paper read to the Institute of Electrical Engineers by Booth, Clark, Egginton and Forrest (27). The use of 400 kV lines had been considered as far back as 1950, at the time the 275 kV Supergrid was projected, but there was very limited experience of transmission at that higher voltage and it was feared that they might give trouble "in the salt laden and industrially polluted atmospheres which are so general in this country". At that time experience of transmission at that voltage was confined to Sweden where atmospheric conditions are very different. The result of this 'act of caution', (28) resulted ultimately in a greater expenditure on transmission reinforcement by delaying the advantages to be gained by 400 kV transmission. However, most of the 275 kV lines were constructed so as to make the conversion to this higher voltage possible (29), and at the Central Electricity Research Laboratories at Leatherhead an experimental line at 380 kV to 440 kV had been under test since 1953.

To provide interested statutory authorities with the Board's proposed 400 kV network a statement had been prepared which was presented to representatives of County Planning Authorities at a meeting arranged in conjunction with the County Councils Association. This statement included a map in geographic outline (30) showing the layout of the transmission lines and substations constituting the Supergrid which would be required to meet the needs forecast by 1970.

The lines and substations existing at that time, for which the consent of the Minister of Power had been received, are shown coloured green. The additional line routes and substation sites proposed by 1970 are shown coloured red. Coloured blue are further lines that the Board thought may be necessary if the load growth in the Southern part of the country continued at the 1961 rate, or if more new generating stations had to be built on the Thames estuary or on the Midlands or Northern coalfields.

The Supergrid network as envisaged by 1970 would total 3,400 miles with possible further extensions of 300 miles, and requiring 133 substations.

The greater part of the network shown on Map No. 5 was intended to operate at 400 kV by 1970. This part, comprising some 70% of the total route mileage of Supergrid line, is identified by the thick lines. Those sections of the Supergrid network which were required to remain operating at 275 kV in 1970 are identified on the diagram by the thin lines. They are confined to areas that are main centres of population and industry, where the electricity demand is substantial and concentrated. Here 275 kV is used to provide high-power distributing facilities, and in many cases would become a substitute for 132 kV. The Board claims that the economic and technical advantages of retaining 275 kV in these areas of high load density are that it provides the requisite large-capacity distribution facilities in an economic manner and without significantly greater line mileage than would be needed with 400 kV. The problems of undergrounding in built-up areas were expected to be less acute, and the substations would be smaller and pose fewer practical problems of siting and construction.



Map No. 5 - 400/275 kV Supergrid, proposed in 1961 for development by 1970.

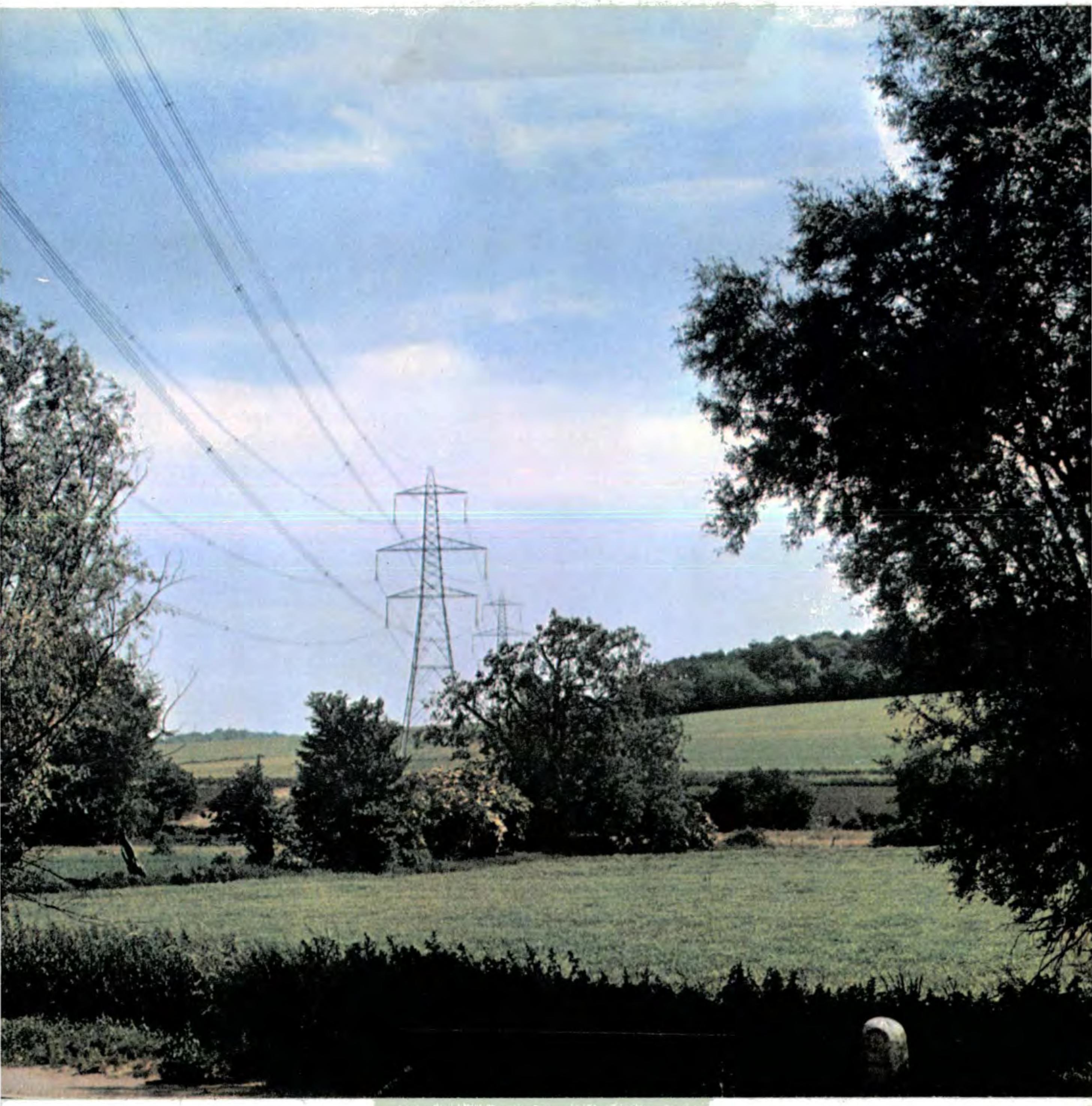
It will be apparent from Map No. 5 that a substantial part of the total mileage of the new Supergrid line was required to extend the area served by the existing 275 kV network. These extensions were necessary to connect the new generation stations proposed at Trawsfynydd and Festiniog in North Wales, and Sizewell in Suffolk and to distribute supplies from the concentrated power sources to demand centres widely spread geographically, as along the south coast. Two new trunk lines are also shown between Yorkshire and Lancashire. These would carry bulk power from coalfield power stations in Yorkshire to the industrial areas of Lancashire and Cheshire, and were required to help meet the rapidly growing power deficits of those areas. The lines would cross the industrial West Riding and would also be used to carry power to that area.

The Generating Board took five years from the time they decided to construct a 400 kV network to the time that the first heavy duty line was commissioned. This was in June 1965 when a 150 mile 400 kV line between West Burton and Sundon substations was energised (31). Since then 1,146 route miles of line have been built and diagram No. 2 shows the rate of construction that has been achieved by the Board during the past three years. It will be necessary for the Board to maintain the present rate of construction if the 1970 programme of between 3,400 to 3,700 miles of Supergrid line is to be in service.

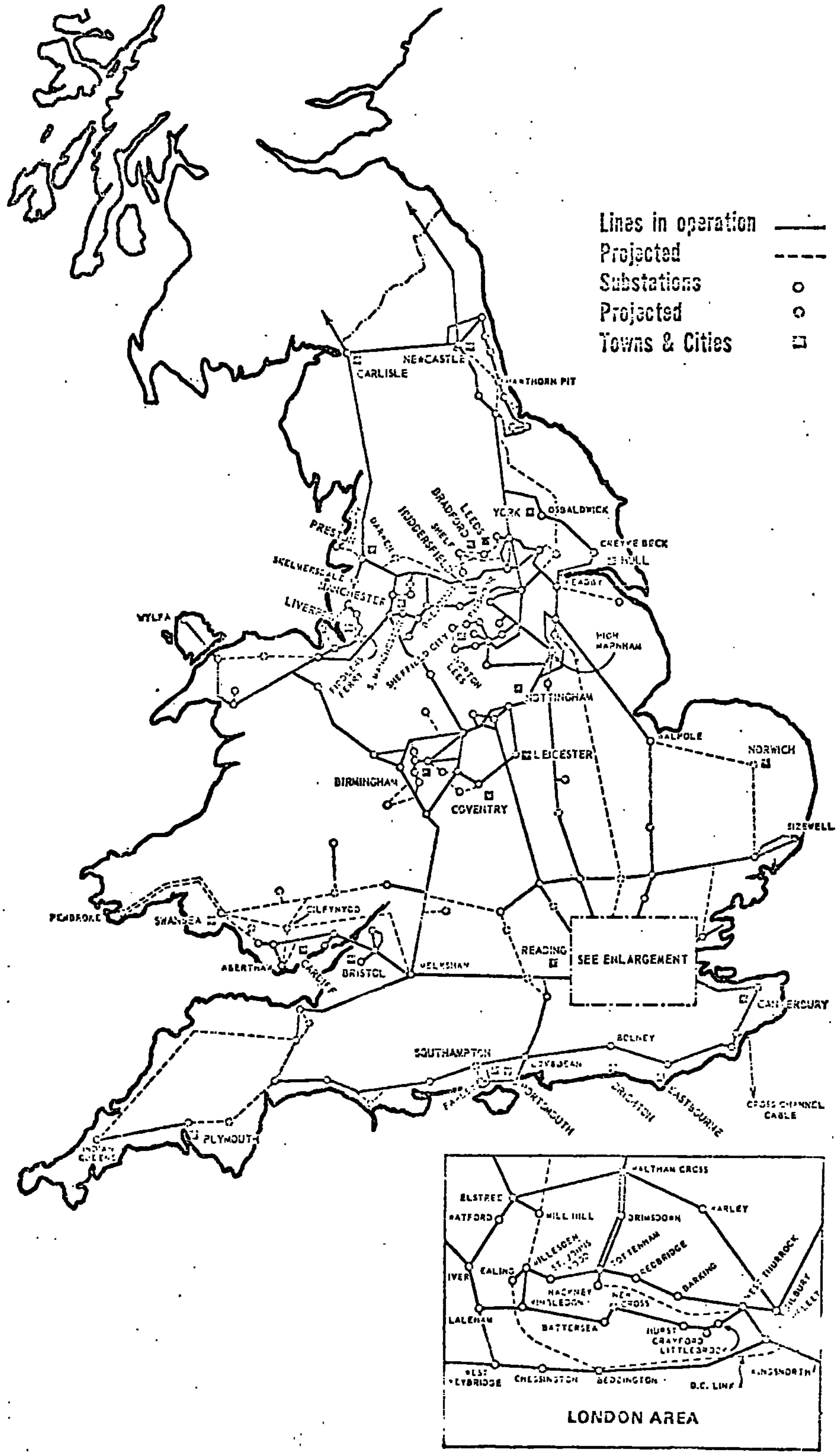
Map No. 6 shows the extent of the Supergrid up to the end of March 1968, and it will be seen by comparing Map Nos. 5 and 6 that the main structure of the originally proposed 400 kV Supergrid has now been largely completed. Several minor changes in detail from the original proposals have been made as construction has proceeded. These have arisen

Frontispiece.

A section of the 275kV Elstree - Tilbury line near Theydon Mount.



Photograph 1. A section of the West Burton - Sundon Line which was the first section of the 400kV supergrid to be commissioned in June 1965.



Map No. 6 - 275 kV/400 kV Supergrid in 1968 principally because of the construction of power stations whose location were not known at the time and because of the difficulty of finding sites and obtaining planning permission for substations, particularly in urban areas.

An attempt has been made to find out the cost of constructing the 400 kV Supergrid and Appendix B tabulates the only reliable data one has been able to find. It will be seen that the figures do not differentiate between costs attributable to Grid or Supergrid construction, and the actual construction costs were not regularly published in the C.E.G.B. Annual Reports. However, by relating the mileage constructed and the actual cost stated in a particular year, to the total mileage of the 400 kV network, it is estimated that the total cost would be in the order of £600m to £700m.

2.7 Possible future transmission developments

A reading of the Electricity Council and C.E.G.B. Annual Reports provides evidence that the Generating Board is carrying out a considerable amount of transmission research particularly at the Board's laboratories at Leatherhead. The Board also sponsors research at the Universities, as well as by the manufacturers of high voltage equipment.

Most of this research seems to be directed towards improving the equipment and operation of the existing transmission system, (32) which is unlikely to alter the main concept or physical appearance of the network. There are however, two transmission developments that could have a considerable effect on the supergrid if widely adopted; these are high voltage direct current transmission, and the adoption of 700kV for the supergrid network. These seem to be the two most promising possibilities.

High voltage direct current transmission.

The Board has shown an interest in d.c. transmission for over ten years since the cross-Channel cable scheme for direct current transmission between Dungeness and Boulogne was projected. (33) This scheme has now been operating satisfactorily for several years, and on the basis of the experience gained the Board have embarked on another d.c. link to reinforce supplied to the London area. It will carry power from Kingsnorth Power Station near Rochester to a receiving station at Beddington near Croydon and another at Willesden. The scheme which will have a length of 51 miles will cost about £16 million and have a capacity of 640 M.W. It will be so arranged that either an isolated generator or the 400kV Supergrid or a combination of both can be used to feed the d.c. link. At the two receiving ends power will be fed into the 132kV system.

It seems that electrical losses are reduced by d.c. transmission, but there is the cost of the equipment required at each end of the link to change a.c. to d.c. and back to a.c. This increased cost is only justified when the d.c. link is not less than about 50 miles. The Board has stated that this installation although more expensive than a comparable alternating current scheme, is in the nature of a research project as it has been designed to permit various modes of operation to help determine the scope for d.c. transmission in the future. (34)

The future grid will be required to transmit large amounts of electrical power over relatively long distances from the generating stations to the main urban centres, and the indications are that d.c. transmission may prove to be more economical than a.c. for this purpose.

700kV Transmission

As long ago as 1961 Sir Christopher Hinton said in a paper at the British Electrical Power Conference (35) that looking ahead to the mid 1970's the Board in adopting the 400kV supergrid was making the assumption that a voltage of 700kV would be practicable by that date and research to ensure that was being started. The following year in evidence before a Parliamentary Committee (36) he said that it may be necessary to superimpose on extra high voltage large mesh network over the 400kV system. The Board had in mind a voltage working at about 750kV and had already started some preliminary research work on this.

The interest shown in the possibility of transmission at such high voltages was increasing and led to a parliamentary question in June 1964 (37) when Mr. Errol speaking on behalf of the Minister of Power said that the Board were studying the economics of overhead a.c. transmission up to 800kV, and that research was being carried out on power losses, radio interference and the design of insulators. A few months later (38) the Chairman of the Board confirmed that such research was still in progress, which was further acknowledged by the Electricity Council in their 1965 Annual Report (39)

Research studies of this kind to assist the choice of a new transmission voltage of 700 - 750kV, and to gain experience in the operation of direct current links, are seen to provide the background information to the preparation of annual programmes of generation and transmission construction, which should be planned to take advantage of the latest developments as they emerge.

2.8 Conclusion

The original function of the 132kV grid, which was interconnection within self-sufficient areas, has evolved into interconnection on a national scale at 400kV, with, in addition, significant peak power flows from coalfield power stations, the whole system being operated as an entity under the direction of a National Control.

The supergrid has developed from forecasts of the geographical patterns of electricity load growth, and the location of new generating stations to supply that growth. It rests on the assumed continuance of generation and transmission techniques that exist or can be forseen today. It is however possible that due to the accelerated change in the respective economic advantages of the various fuels for generation, and changes in the overall rate of load growth, the present supergrid which should be sufficient until 1980 may require some major amendments.

The assumptions that are made in forecasting the future patterns of electricity demand and generation are so general that great accuracy is not claimed for the resultant estimates of long term transmission needs. The broad indications are of increasing emphasis on the transmission of power to widely dispersed points of supply from concentrations of generation in peripheral oil fired and nuclear stations as well as those sited on the central coalfields. It is thought that these requirements are likely to be met by a multi purpose 400kV supergrid network with main trunk lines transmitting at 700kV or by direct current with completely automatic computorised national control of the system.

CHAPTER TWO

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30. Statement on the Development of the 400/275 kV Supergrid Transmission Network in England and Wales. June 1961. A copy of the original C.E.G.B. map included with the Boards 1961 statement is included at the back of this thesis as map No. 13.

31. The Electricity Council Annual Report 1965 - 66 page 51 para. 160.

32. For example, improving the design of insulators, transmission towers, silencing of circuit breakers, equipment for reactive compensation and similar technical matters with which the writer is not competent to deal.

33. C.E.G.B. Annual Report 1959 page 30, also Annual Report 1961 page 4.

34. C.E.G.B. Annual Report 1966 page 4 para. 17. Times 26.4.68.

35. The British Electricity Transmission System, Sir Christopher Hinton Chairman of the C.E.G.B. British Electrical Power Conference Eastbourne 1961.

36. Sir Christopher Hinton as Chairman of the C.E.G.B. was giving evidence before the Select Committee on Nationalised Industries on 2nd May, 1962. Report published H.M.S.O. 28.5.1963 Vol. I para. 435. Vol. II para. 898.

37. Hansard. House of Commons. 2 June 1964. Vol 695. Col. 156. Question asked by Mr. Lubbock.

38. The Times 1st September, 1964 reprinted as a C.E.G.B. Newsletter No. 44 in September, 1964.

39. The Electricity Council Annual Report 1965 page 46 para. 140 "In the field of transmission, research work has been concentrated in existing transmission voltages up to 400 kV, with a smaller effort on higher a.c. voltages". The Financial Times 30.1.69 reports that joint research between the C.E.G.B. and the French and Italian power authorities is currently being carried out into the design of overhead lines of 765 kV.

CHAPTER THREE

The Pattern of Generation and Transmission of Electricity

3.1 Introduction

Many economic comparisons have been made between the cost of transporting energy in the form of electricity, and in the form of coal by road, rail, and sea, and also of pushing oil, gas and even coal through pipelines. There seems to be a general opinion that oil by pipeline is the cheapest of all methods. These studies are, however, of little more than general interest unless actual terminal conditions and ultimate utilization are taken into account.

This chapter will examine what these conditions are, the effect they will have on the siting of power stations and the direction of power and energy flow.

The pattern of fuel supplies and the economics of energy movement have brought about the post war expansion of coal-burning electricity generation near the central coalfields, of oil-burning generation near major refineries or oil terminals, especially in the south of England, and to the development of nuclear power to meet the demands that are most difficult to supply from the other two sources. The practical problems of power station siting, especially that of water for cooling will be discussed.

The geographical pattern of electricity consumption is very different from that of coal production, and the effect of this on the economics of energy movement, and the economic justification for the Grid and Supergrid transmission network will be examined.

3.2 The Pattern of Generation - Coal, Oil and Nuclear Power Stations

There are three main primary fuels for the generation of electricity, and each fuel introduces varying influences in determining the most economic siting for a power station. The siting criteria for each form of fuel will be examined.

The Siting of Coal Burning Power Stations

The siting requirements of coal-burning power stations are continually changing with advancing technology. The greatest changes in the post-war period have been consequent upon the increase in the size of individual power stations. Coal-burning power stations now being built are generally of 2,000 MW capacity, are of higher thermal efficiency and have greater requirements for cooling water and coal supplies than stations commissioned a few years ago. They have individual generating units of up to 550 MW compared with the usual 60 MW of the immediate post-war period. West Burton on the Trent Valley of 2,000 MW generating capacity will burn approximately 20,000 tons of coal daily when on maximum load, and two other stations at Didcot, and Kingsnorth of this size are under construction.

The Trent Valley below the town of Burton has been developed with by far the largest single concentration of new generating capacity in Great Britain. This is a response to cheap low-grade small coal from the Derby, Nottingham and Leicester coalfields, reasonable proximity to the expanding industrial areas and, especially, the presence in the River Trent of the largest supply of cooling water in eastern England. This siting in the Trent Valley is thought to represent the present optimum in economic coal-fired power station location. The tonage made available by the National Coal Board from the East Midlands in the preceeding four years has been virtually static at about 19.25 million tons, 1968 - 69 the tonage supplied increased to 19.6 million tons. The tonage supplied from the Yorkshire coalfield has increased annually to a present level of 18.5 million tons.

The other main location pattern for coalfield stations has been on estuaries, close to markets, to which coal can be carried reasonably cheaply by sea, for example along the lower Thames.

A 1,000 MW station needs 30 million gallons of cooling water an hour, where the water is only used once and returned direct to sea or river. Less is required in the closed circuit system, used of necessity in most of the riverside power stations, but this is expensive and less efficient.

The possibilities of hydraulic and pneumatic methods of transporting pulverised coal through pipelines is being studied by the Board (1). In circumstances where supplies of coal from particular groups of collieries to individual power stations can be expected to be stable for many years, this method of energy movement may reduce the cost penalty of siting power stations at a distance from the coalfields. In the meantime economics in coal handling of power stations are being made by the introduction of "merry-go-round" coal trains with a load of 1,000 tons which is discharged through bottom hopper doors which are automatically opened and closed as the wagons pass over below track conveyor belts. This method was first introduced at Ratcliffe-on-Soar power station in Nottinghamshire which was brought into service in 1968.

There remains the difficulty in finding sites for coal fired stations that inland water resources in central southern England are inadequate for any substantial additional generation even using cooling towers. A 120 MW dry-cooling tower has recently been brought into service at Rugeley Power Station and this system, if successful, may enable power stations in future to be sited independently of large natural supplies of water. The capacity of a cooling tower can be increased or the size for a given capacity decreased by employing assisted draught. The Board has switched the emphasis of its design study from the largest dry cooling tower which is about 300 ft. in diameter and 375 ft. high to investigating a range of towers of different heights, each capable of cooling a 66 MW generating set. The tower height appropriate to a particular site can then be chosen so that the gain in amenity can be balanced against the economic penalty imposed by assisted draught.

The Location of Oil Fired Stations

Fuel oil, despite a tax equivalent to more than a third of its basic cost, is increasingly competitive with coal in many locations, and have much the same detailed siting requirements as coal burning stations, but are usually located on estuarine sites away from the coalfields. They require deep water anchorages for the oil tankers and there is an economic as well as operating advantage to site them adjoining refineries. Three oil fired stations are under construction at the moment, one at Fawley on Southampton Water, is close to the largest oil refinery in the country; another is at Milford Haven in South Wales where two refineries are operating and a third is planned, and a 2,000 MW station at Kingsnorth on the Medway Estuary which has been designed to burn either coal or oil.

The Siting of Nuclear Power Stations

Nuclear energy has enabled the siting of nuclear power stations to be entirely free from the limitations imposed by the extensive fuel transport facilities required for the running of a coalfield power station, but on the other hand it requires a greater quantity of cooling water than a conventional station of equivalent output. A nuclear power station of 500 MW needs 35,000,000 gallons of cold water per hour, which is about twice as much as an equivalent coal fired station. No river in England and Wales is able to supply such a volume of water throughout the year, and for this reason all the existing and proposed nuclear stations, with the one exception, Trawsfynydd, are sited on the coast or on large tidal estuaries. (2).

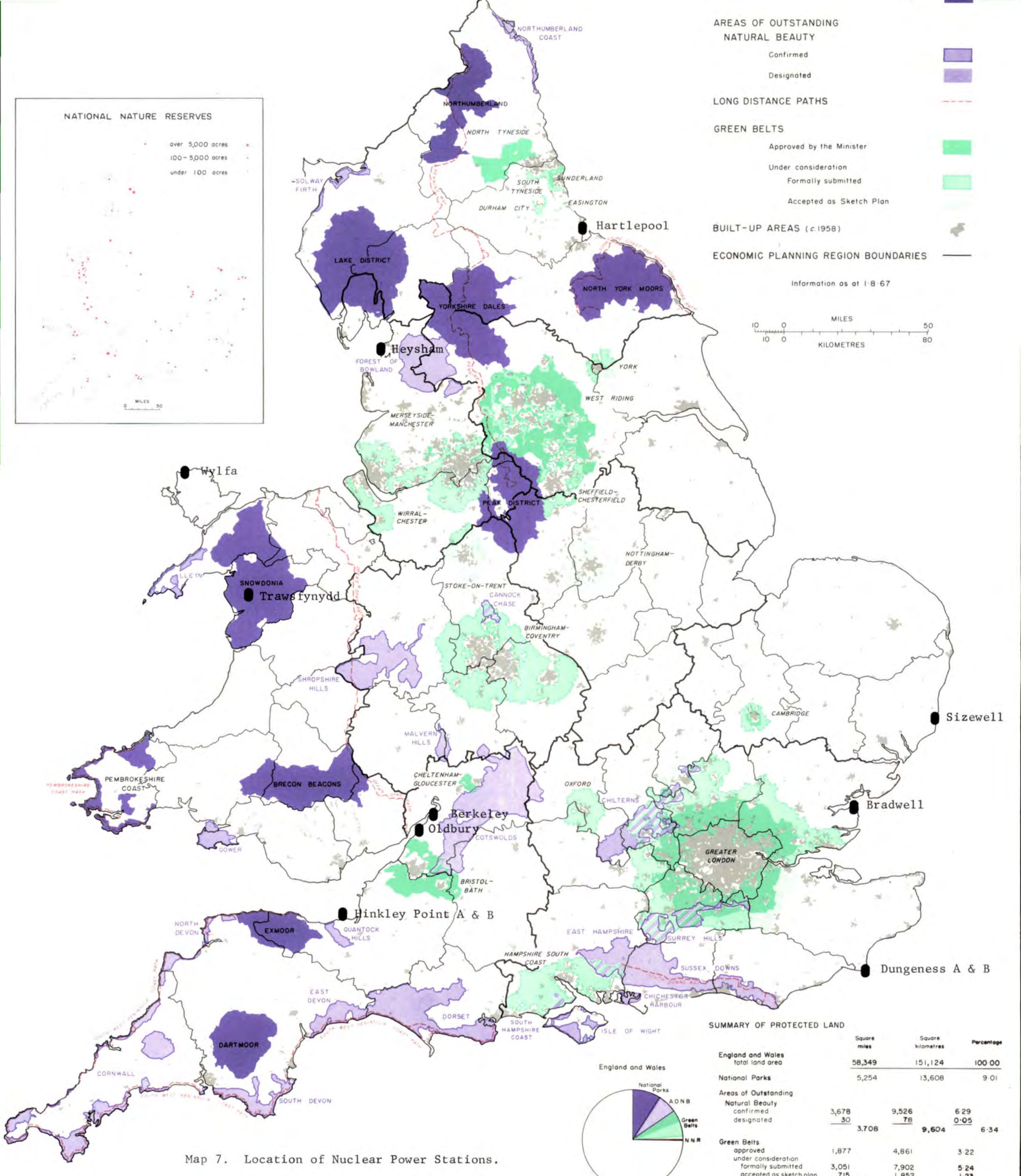
Although the space occupied by the power station and ancillary buildings is no greater than for a conventional station, an area of about 100 acres is usually required. (3).

The next most important factor was the Government's policy of siting nuclear power stations away from built up areas, as shown on Map 7. The nuclear reactors at present being designed for the Board have certain self regulating characteristics, and there are many protective devices to ensure safe operation and control. However, in the apparently very remote eventuality of an escape of radioactivity, the monitoring, radiological control, and public safety, were best served in thinly populated areas. This policy of siting nuclear power stations away from built up areas was in conflict with the economic advantage of generating electricity close to the load centre.

The most recent design of nuclear station as adopted for Dungeness 'B' will require only about 10% more water than a contemporary coal fired power station (4). For this reason nuclear power stations may no longer be restricted to the coast, and there is thus an added incentive to re-examine the other siting requirements.

It is essential in order to achieve the economic operation of nuclear stations with their high capital cost that they should be connected to the national transmission system. Since the cost of a unit of electricity produced by a nuclear power station is the same wherever the station may be, they can make their most economical contribution to the nation's power requirements if they are remote from the coalfields, and as close as possible to the load centres which would otherwise depend on importing energy in the form of either coal or electricity produced further away. The south of England, which has negligible supplies of coal, and an electrical demand approaching half that of the whole country has to import energy. Similarly

Map 7. Location of Nuclear Power Stations.



SUMMARY OF PROTECTED LAND

	Square miles		Square kilometres		Percentage	
England and Wales total land area		58,349		151,124		100·00
National Parks		5,254		13,608		9·01
Areas of Outstanding Natural Beauty						
confirmed	3,678		9,526		6·29	
designated	30		78		0·05	
		3,708		9,604		6·34
Green Belts						
approved	1,877		4,861		3·22	
under consideration						
formally submitted	3,051		7,902		5·24	
accepted as sketch plan	715		1,852		1·23	
total		5,643		14,615		9·69
National Nature Reserves		101		263		0·17
		14,706		38,090		25·25
Adjustment for areas included in more than one category		431		1,117		0·74
TOTAL		14,275		36,973		24·47

Map 7. Location of Nuclear Power Stations.

Lancashire and North Cheshire with heavy industrial loads, also have to import electrical energy, because there is insufficient local coal of the low grades used in power stations and therefore there is considerable economic advantage to be gained by siting nuclear stations in these areas (5).

Because of their low running costs, nuclear stations are operated to supply the base load, and up to the present they have been so sited to meet the growth of demand where indigenous fuel is scarce or costly. All the nuclear stations so far constructed have been sited in accordance with the remote siting policy adopted for the first nuclear programme in 1955. As nuclear power becomes progressively cheaper compared with power from fossil fuels, there will be a tendancy to site nuclear stations nearer to the source of demand in order to reduce the transmission connections. For the past few years the C.E.G.B., the U.K.A.E.A. and the Inspectorate of Nuclear Installations have been studying the possibility of changing the siting criteria to take account of the improved safety characteristics of the most recent design of reactors. In February 1968 the Minister of Power announced on the advice of his Nuclear Safety Committee that future nuclear stations may be sited much nearer to built up areas than has so far been permitted subject to individual consideration of each proposed site, and that the proposed new stations at Seaton Carew, near Hartlepool and at Heysham were to be considered in the light of these recommendations(6). He later, in reply to a Parliamentary question said that he was considering the possibility of publishing a short White Paper setting out the considerations and principles recommended by the Nuclear Safety Advisory Committee (7).

At the time of writing the C.E.G.B., is investigating the possibility of siting a nuclear power station adjoining the River Tamar in Devon within 10 miles of Plymouth, which would be closer to a dense centre of population than any existing nuclear power station (8). The result of this trend will be that the existing pattern of nuclear power station siting will slowly change and it is quite possible that within a decade nuclear stations may be constructed in the built up area of large towns.

Reference has been made to coal, oil and nuclear fuel; there is at the moment no other fuel likely to be available to the C.E.G.B. in any significant quantity to affect the present position of power station siting. The Board has undertaken research studies into other forms of direct generation of electricity which employ thermionic diodes, fuel cells and magnetohydrodynamics or plasma techniques. It is not thought that any of these methods has yet produced electricity commercially.

Natural gas from the North Sea is also currently under investigation by the Board. A pilot scheme for the conversion of a coal fired station to natural gas was undertaken at Hams Hall power station (9) and experience is being gained in its use. It is too soon to forecast with any certainty the extent to which natural gas will be used for this purpose in the future. The extent of hydro-electric schemes and pumped storage are unlikely to be sufficiently significant to affect the main geographical pattern of generation in England and Wales.

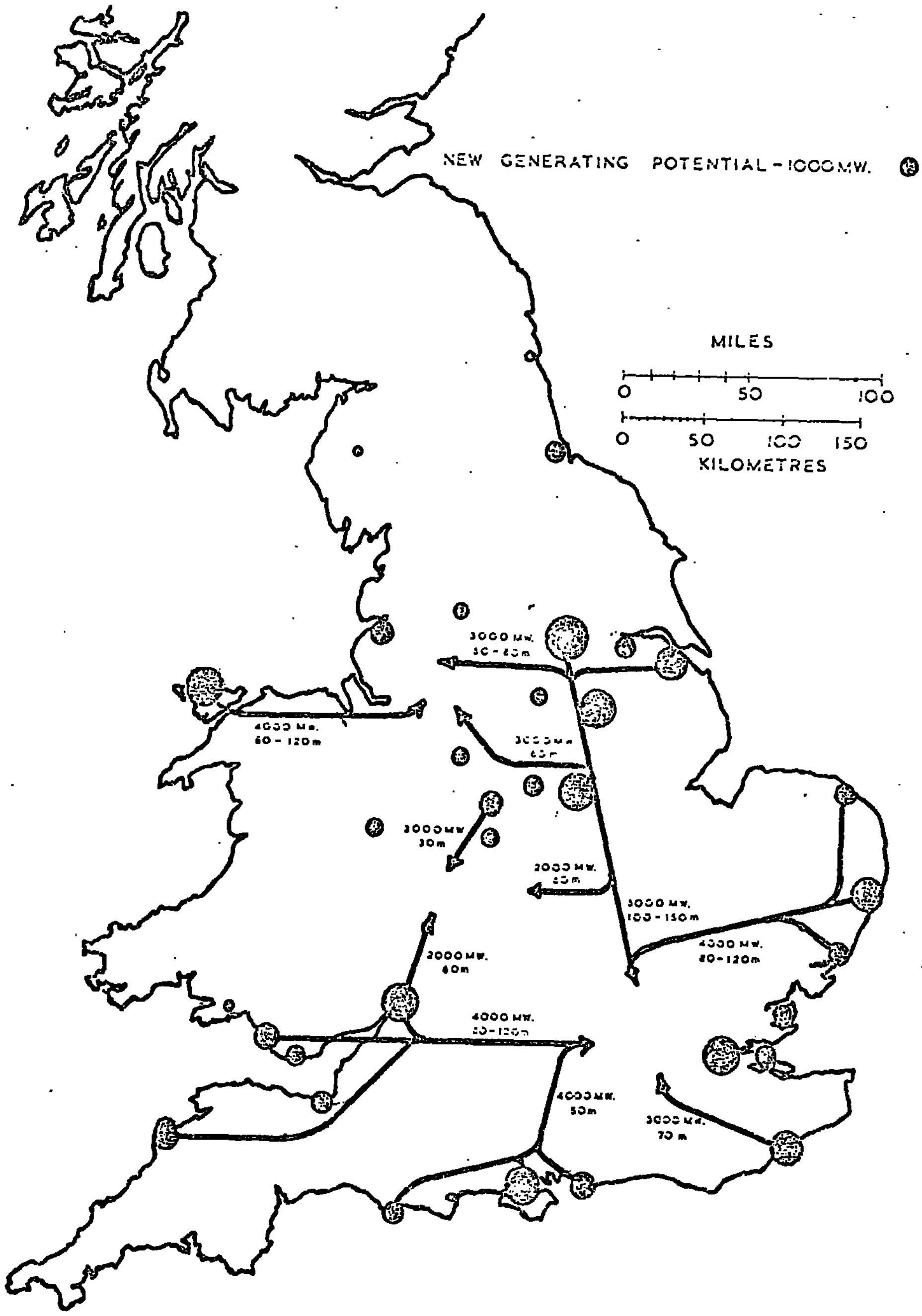
During the financial year 1968 - 69 the Board used some 6 million tons more of coal than would have been justified if they had been permitted to operate solely on the most economic fuel. The Government fuel policy to assist the coal mining industry being implemented under the Coal Industry Act 1967 enables the Board to be partially reimbursed for the financial loss it incurs. The Board has estimated that by 1970 the total fuel used will be about 100 million tons coal equivalent per year; about three quarters will be coal and the remainder divided between oil and nuclear (10).

3.3 Geographical Pattern of Power Flow

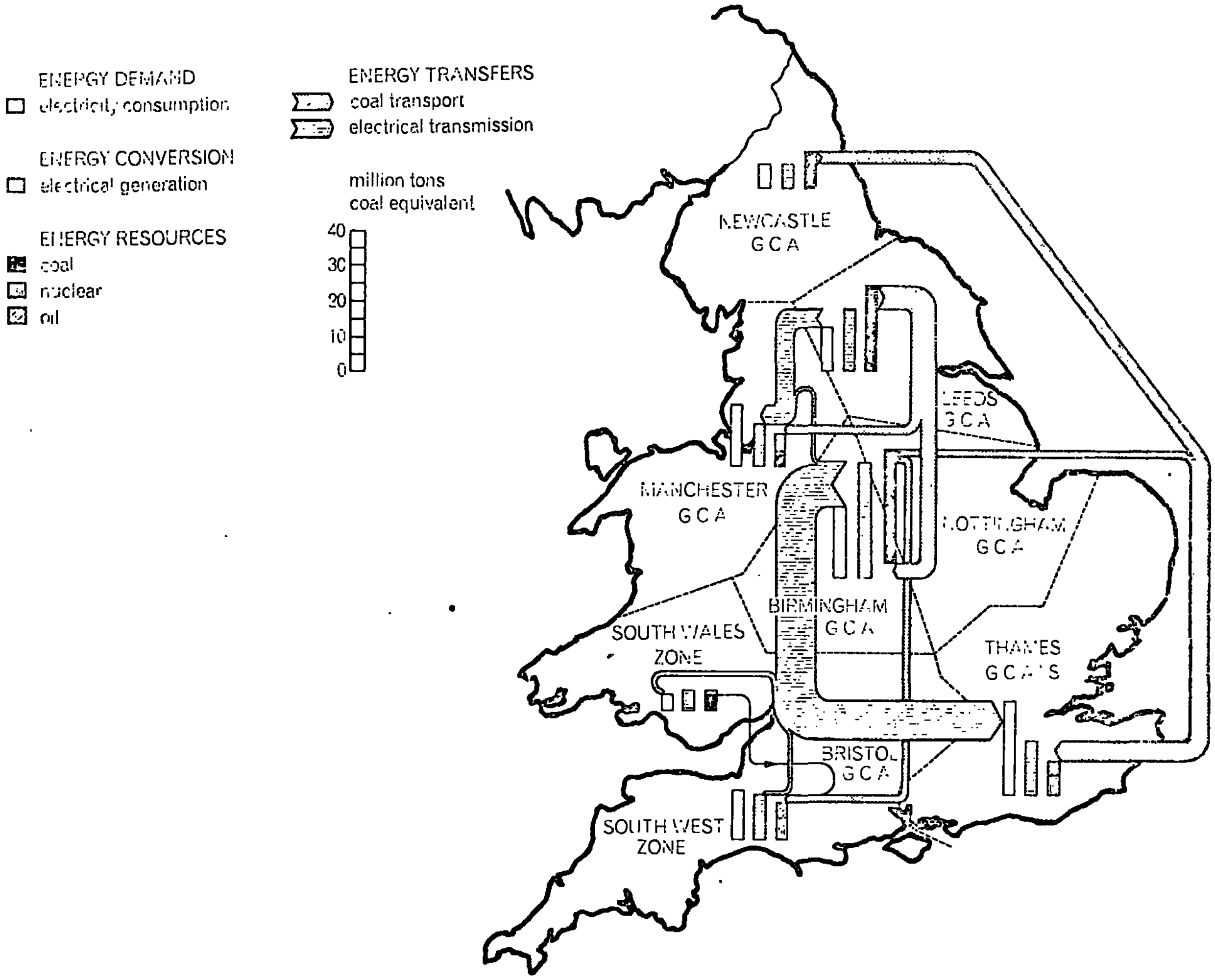
The shape of the transmission network is determined by the geographical patterns of the consumers' demands for power, and of the location of power stations. The siting of new generating plant depends in the first instance on technical and economic suitability the main features of which have already been discussed. In order therefore to appreciate how a programme for transmission reinforcement is prepared it is necessary to review how the future estimates of the demand for electrical power is assessed. In March of each year the Electricity Council reviews the load forecasts five years ahead as a basis for the programme of construction of new power stations and transmission lines. The maximum demand on the system last year was for 35,818 MW (11), which was smaller than anticipated. The Council's load forecast for the winter of 1972 - 73 was for 54,000 MW (12) and this figure was readopted for 1973 - 74 (13). This slower rate of increase in maximum demand reflects the Council's assessment of the effects of devaluation and the Government's economic measures. The present forecast represents an average anuual growth rate of 7.2 per cent, which is roughly equivalent to doubling over ten years. This forecast falls far short of the expected demand of 70,000 MW by 1971 which the supergrid had been planned for in 1960. There is at the present time a substantial margin of generating plant capacity which because of stations already under construction will tend to increase still further until about 1973 unless the annual growth rate for electricity increases considerably in the meantime. At the present rate of increase a maximum demand of 70,000 MW should be reached by 1980 and at that time if the pattern of generation envisaged today is followed, the existing large concentration of power stations on the Nottingham coalfields will be exceeded jointly by other concentrations in North Wales, the Bristol Channel, the Central South Coast, the Thames Estuary and South East Kent and the East Anglian Coasts. About two-thirds of the peak demand to be supplied from the new power stations will be used in Greater London, the South Western, Midlands and the North Western areas. The general level of bulk power movement, shown diagramatically on Map No. 8 (14), is in the region of 4,000 MW over distances of 50 to 100 miles, but transfers of blocks of power up to 8,000 MW from the central coalfields towards the West Midlands conurbation, and 6,000 MW to the London area, a total distance of 100 to 140 miles, are likely to be required.

The policy of concentrating as much coal fired generating plant as possible on the Midlands and Yorkshire coalfields as illustrated on Map No. 9 (18) which shows that a larger amount of energy is expected to be transferred electrically to the South and North West from these areas, than is undertaken by transporting coal.

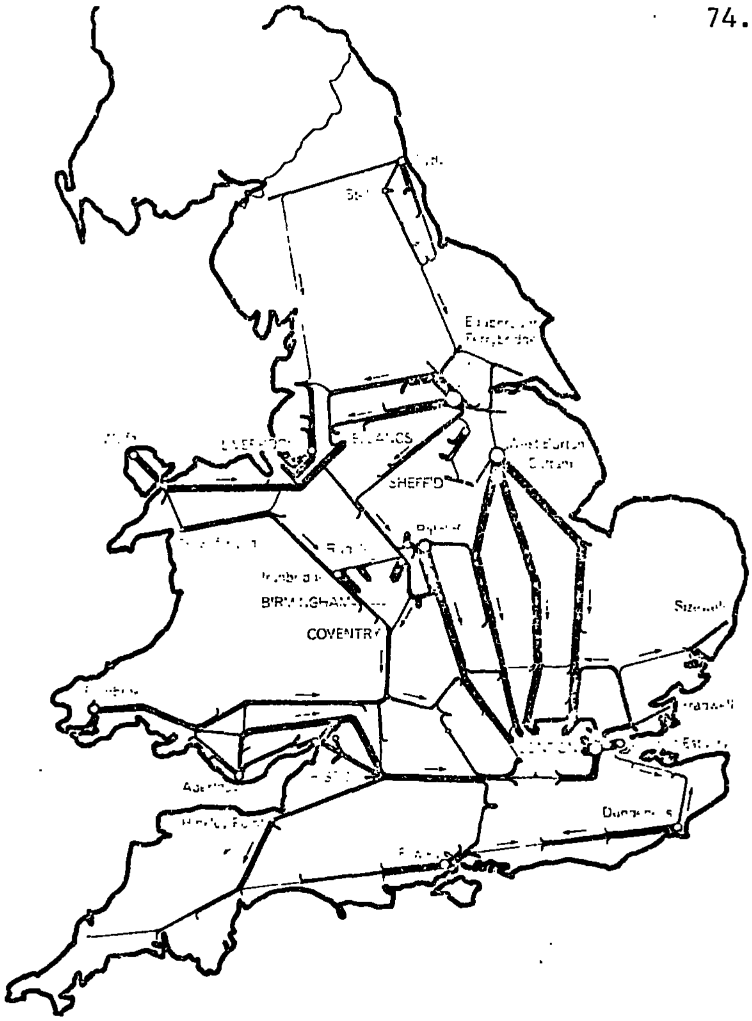
The geographical pattern of the supergrid as planned in 1960 to meet a total demand of 70,000 MW is shown on Map No. 12, and is the practical result of meeting the anticipated electrical power flows shown on Map No. 10 (15). The power flow shown represents just over half the total electrical demand in 1980; the remainder will be provided by generating plant nearer to the load centres and carried by the lower voltage networks. The major power sources are illustrated by the circles, the diameter of circle representing to scale the power available for export after local needs have been met. The coloured strips indicate the route along which the power flows, the direction being always towards the vee point. The width of the strip represents to scale the magnitude of the power flow. The map shows substantial power imports into the Greater London area, these being derived mainly from power stations on the Thames Estuary and from others on the East Midlands coalfields, but with some assistance from stations on the Severn estuary and on the south coast. Appreciable power imports are also required into the North Western



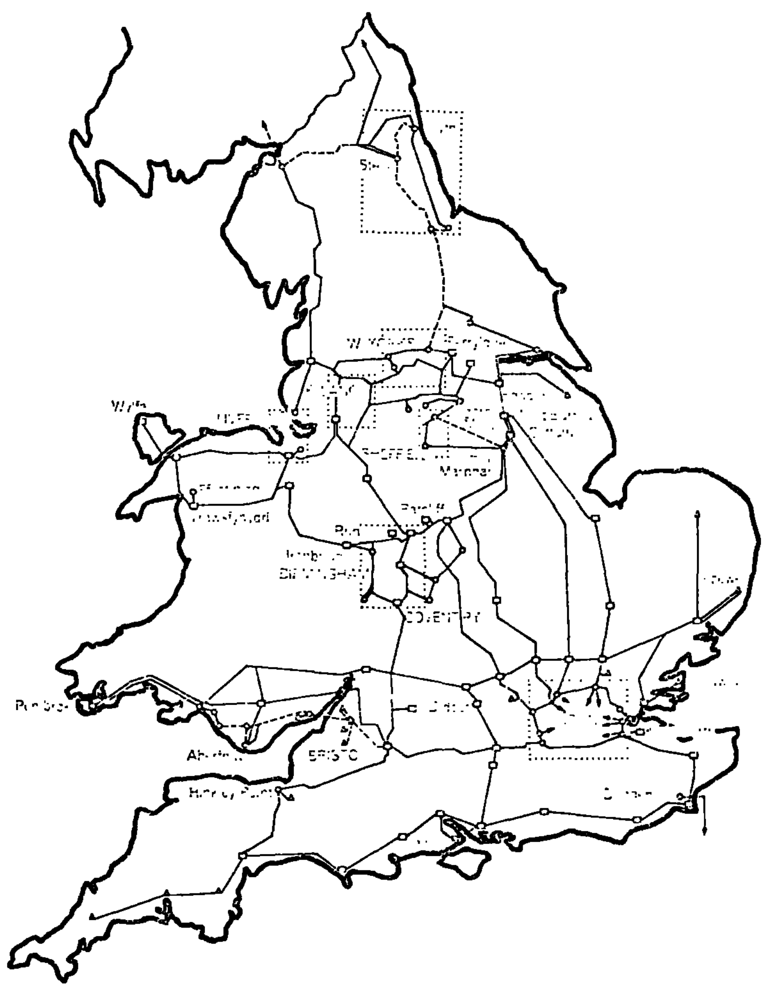
Map No. 8 - Principal power flows anticipated when electrical demand reaches 70,000 MW



Map No. 9 - Estimated energy transfers in 1980/81



Map No. 10 -
Estimated winter
peak power flows
in 1980/81.



Map No. 12 -
Main supergrid
network planned
for 1980/81.

area, these being derived partly from power stations on the Yorkshire coalfield and partly from nuclear stations in North Wales. Along the south coast the centres of demand are spread over an area extending some 300 miles from Kent to Cornwall and absorb practically the whole of the available power from the three major sources at Hinkley Point, Southampton and Dungeness.

It will be observed that certain channels appear to carry comparatively little power, but the power flows illustrated are those which are expected to occur at the time of winter peak demand with all conditions in accordance with average expectation. Even in normal conditions, however, because electricity demand varies greatly from hour to hour, day to day, and season to season, the power flows will also vary greatly. Still more will they vary in the event of exceptional circumstances such as failure of major items of transmission equipment or generating plant. The lightly loaded channels are therefore complementary to the more heavily loaded channels serving the same section or area. This disposition of supply and demand of electricity has necessitated a reticulated transmission system with countryside coverage.

The maximum transmission capacity required purely for interconnection purposes, even between two halves of the 70,000 MW system, is estimated from past experience to be about 3,000 MW. Moreover, it appears that the total power fed on to the high voltage system at times of peak demand will be over 50,000 MW out of 70,000 MW and this must be distributed to the lower-voltage networks at widely spread supply points. These figures indicate that we may see a gradual change in the function of the transmission system over the next 15 years. Bulk power transfers from practicable generating sites to dispersed supply points are likely to assume increasing importance, and interconnection requirements to exert less influence on the future network structure.

3.4 Operation of the Transmission System

In meeting the demands of electricity consumers, the Board arranges for the maximum amount of generation to take place at those power stations which can generate most cheaply, and the minimum amount at stations where generation is expensive. The cheapest generation occurs where coal is cheap and the generating stations are large and efficient. These are almost invariably modern stations erected on or near the coalfields in the Midlands and North. The most expensive generation takes place at the old stations which are least efficient and usually where the coal price is high. These stations only run for a few hours in the morning and the afternoon during the winter months in order to meet the peak loads on the system.

All plant needs to be maintained and wherever a highly efficient generating set is out of service its output has to be made good by some other and less efficient generating plant. The additional cost of not running highly efficient generating plant can be very considerable, for example, putting a 200 MW generating unit in the Midlands out of service could increase the total costs of generation by something of the order of £8,000 per day. As the maintenance of a large unit of this type requires about 28 days in a year there is a strong economic incentive to reduce this period. The Board have experimented with 'crash overhauls' to see how far this maintenance period can be reduced, and the Board says that techniques have been developed which can produce appreciable reductions in the time required for servicing.

One of the special problems in running the Grid system is to ensure that the maximum amount of generating plant is available during the winter months of December and January during the period of peak demand. This can be done only by ensuring that all overhauls of plant and lines are carried out completely during the remaining ten months of the year and that the incidence of breakdown is kept to a minimum.

The outputs of the generating stations in England and Wales are co-ordinated by a National Control Centre in London, through seven Regional Control Centres at Newcastle, Leeds, Manchester, Birmingham, Bristol, Thames North and Thames South. There is also a tie-line to a Scottish Control Centre in Glasgow over which an interchange of energy is arranged between Scotland and England on a day-to-day basis.

3.5 The Economic Justification for a Transmission System

The justification for a transmission system, is that it is cheaper to build one than not to, for the following three main reasons:-

1. By connecting all power stations to a national grid there is a capital saving in the amount of standby plant that is required.
2. It is more economic to run the more efficient generating plant to meet varying demands made on the system.
3. It is more economic to transmit electricity than to carry the equivalent amount of coal.

It is proposed to examine each of these statements, and to see if they can be quantified.

The first beneficial effect anticipated by the establishment of the Grid was a reduction in the amount of plant required to meet a given power demand. A generator held in reserve at one power station could stand by for other generators that might breakdown, or have to be taken out of commission for maintenance. During the pre-Grid period the amount of spare plant to provide against possible breakdowns had been increasing steadily with the rising size of generating units, and the trend is shown in Diagram 3. The reversal of this trend is seen after 1933 when the effect of the Grid had become apparent.

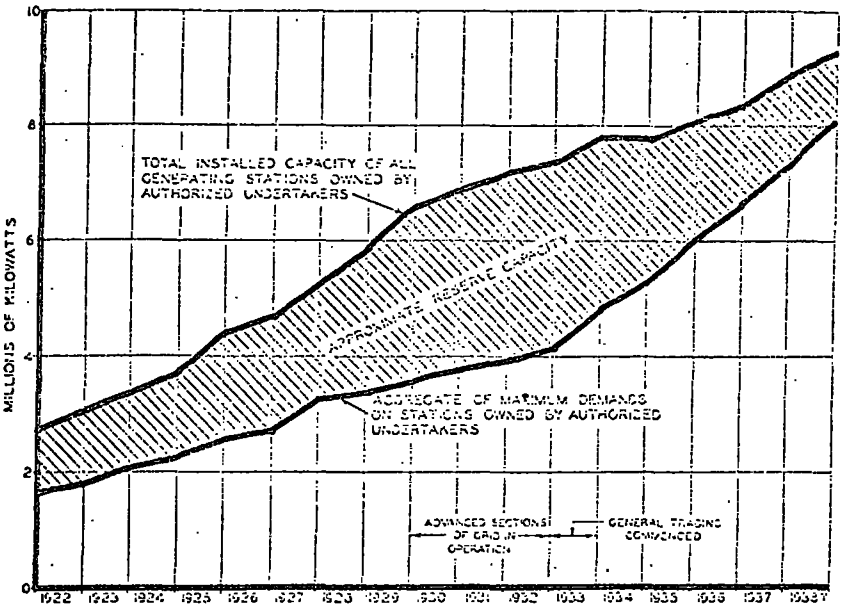


Diagram 3. Effect of Grid on Plant Capacity (17)

Before the Grid came into existence the spare plant margin was of the order of 40 per cent; this has been gradually reduced to 26 per cent in 1936, 15 per cent in 1950, and by 1960 to 10 per cent. Although on occasions since 1960 the margin of spare plant has been less than 10 per cent, the Board has adopted this figure as a reasonable minimum in order not to put the system at risk by making it lower.

Apart from the saving in capital charges the Grid made possible the allocation of load in accordance with cost efficiency enabling the most efficient stations to be run for long periods and the least efficient to be relegated to peak load duty. By 1938 for instance only 30 of the 171 generating stations under the direction of the Central Electricity Board were kept running throughout the year and 14 of the most economical stations supplied 50% of the total units generated (18).

In 1960 it had been estimated that the fuel saving arising from the interconnection of power station to enable the most economic operation was in the order of £35 million a year, and that a further annual saving of £4 to £5 million is achieved by the transfer of large blocks of power between areas.

It has been estimated that the disconnection of a single major transmission line could result in additional generation costs of as much as £10,000 per week (19).

It has already been mentioned that the rising coal requirements of the power stations can only be met economically at present by taking increased supplied from the Midland, Yorkshire and North Eastern coalfields. On the other hand the most rapid growth in consumption of electricity is taking place in southern England. Studies of comparitive costs have demonstrated that it would be cheaper to carry out this energy movement by means of electrical transmission rather than by moving the coal. A 275 kV transmission line with a transmitting capacity of about 1,000 MW would in 24 hours carry the equivalent of 20 train loads of coal which is about the daily consumption of a modern power station. Diagram No. 4 shows the combined costs of transporting coal to a power station of 1,350 MW output capacity, and then transmitting its electrical output at 275 kV to the point of demand. The red lines give the combined costs for power stations situated either at the load centre or at two stated transmission distances from it, and at varying rail transport distances from the coal source. The green lines give costs for power stations sited at two stated rail transport distances from the collieries and at varying transmission distances from the load centre. It must be added that in central England it is possible to site larger power stations near the coalfields where the rivers can provide water for cooling towers, whereas in southern England, because of lack of water, the nearest practicable power station sites to a distribution centre may be as much as 60 miles from it and in the opposite direction to the coalfields. Consequently, the total distance of energy movement is shorter if the stations are built in central England.

The British Electricity Authority claimed that the Supergrid would save in the order of £3,700,000 per annum by 1960, when the majority of the

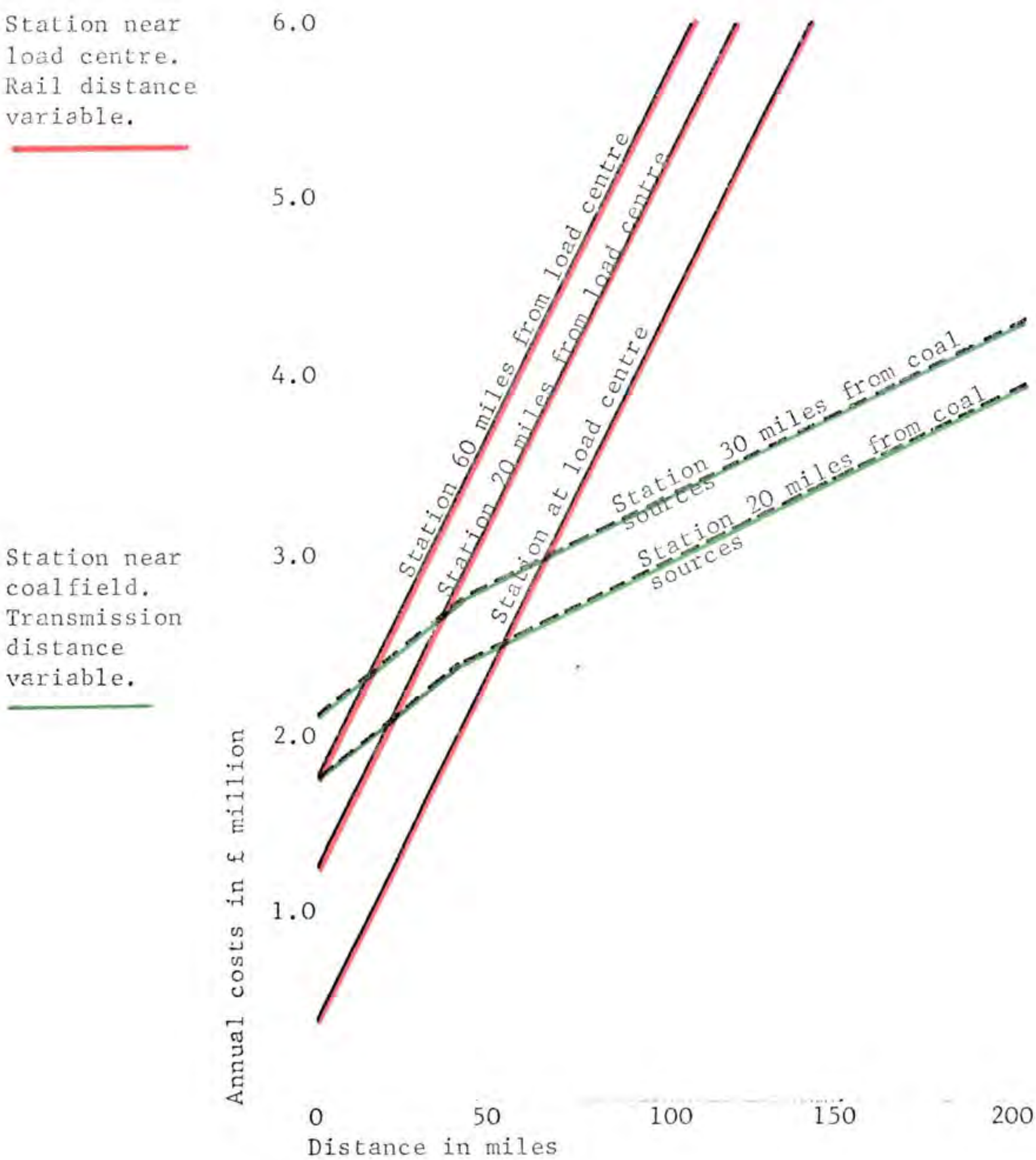


Diagram No. 4 - Annual costs of energy movement by combined rail haulage of coal, and transmission of electricity (20) new Supergrid lines would be in operation. The Authority also claimed that the savings by delaying the installation of generating plant to provide a five per cent additional total capacity would work out at £5.1 m. per annum, and the saving in coal transport, less cost of electrical transmission would be another £3.2 m. making a total of £8.3 m. They allowed £4.6 m. for fixed annual costs and charges for the Supergrid which produced a saving of £3.7 m. per annum (21).

The total cost of the 275 kV Supergrid was £78 m. (22), but is thought by the Board to be completely justified by the saving of the cost of new generating plant that would otherwise have become necessary. The cost of this additional generating plant has been assessed by the Board at £150 m., nearly twice the cost of building the 275 kV Supergrid.

The cost of a 400 kV line is about twice that of a 275 kV line, £54,000 a mile compared with £27,000 a mile, and the cost of associated equipment such as switchgear and transformers are also higher for the 400 kV line. On the other hand the carrying capacity of the 400 kV line is about three times that of the 275 kV line, so that three times the power can be carried for twice the cost (23).

The essential elegance of electrical transmission is its remarkable rapidity and efficiency; 97.5 per cent of all the electricity sent out from generating stations reaches the public. Taking into account capital charges, maintenance, and operation, the total operating costs of the main transmission system amounts to about 3 per cent of the cost of electricity to the consumer.

3.6 Conclusion

There will be a trend towards siting power stations both nuclear and conventional coal and oil, nearer to load centres in order to limit the extent and cost of transmission. Inland siting of nuclear power stations, using cooling towers, close to population centres, are now coming to be accepted. There will also be a place for natural gas generation, and pumped storage schemes for quickly meeting sudden peak loads.

The main transmission network established by the early 1970's is likely to remain adequate throughout the following decade, but among the outstanding problems that still have to be faced in completing the supergrid is the transmission of large blocks of electrical power in a manner acceptable to the public. The effect of this on land use and amenity will be examined in succeeding chapters.

CHAPTER THREE

References

1. C.E.G.B. Annual Report 1960, Page 50 paragraph 217.

2. The sole exception is Trawsfynydd sited at the edge of Lake Trawsfynydd, the largest sheet of water in North Wales, which is adequate to dissipate by surface cooling the heat produced by a 500 MW station.

3. Berkeley has 96 acres.

4. The Future Development of Electricity Supply - Some Significant and Changing Factors by Glyn England, pub. C.E.G.B. July, 1966, p.13.

5. At the time of writing sites for nuclear station are being investigated in South Devon and at Heysham in Lancashire.

6. Hansard H. of C. 7.2.1968 Vol. 758, Col. 185 and 20.2.1968 Vol. 759 Col. 72.

7. Hansard 7.5.68 Vol. 764 Col. 69.

8. Western Morning News 23.5.68.

9. The Electricity Council Annual Report 1967 - 1968 page 28.

10. Meeting Growing Demand for Electricity in England and Wales by E.S. Booth. A paper presented in Brussels to the Annual Conference of the Societe Royale Belge des Electriciens 4th May, 1966, published C.E.G.B. December, 1966 Page 8.

11. The Electricity Council Annual Report 1967 - 1968 pag 19. The maximum demand occurred on the 10th January, 1968.

12. The Electricity Council Annual Report 1966 - 1967 page 24.

13. The Electricity Council Annual Report 1967 - 1968 page 19.

14. The Design and Operation of the Grid System of England and Wales, Clark, Littler and Scott, Sixth World Power Conference Melbourne 20.10.62. Map No. 8 is based on Figure 5, page 1940.

15. This map has been reproduced from page 8 of C.E.G.B. publication Meeting Growing Demand for Electricity in England and Wales, E.S. Booth printed December, 1966.

16. Ibid: page 29. Original larger copies of these Maps No. 10 and 12 are included at the back of this volume as Maps No. 11 and 13. These have been extracted from a C.E.G.B. publication, Statement on Development of the 400/275 kV Supergrid Transmission Network in England and Wales published June 1961.

17. This diagram is based on one published in the Presidential Inaugural Address to the Institute of Electrical Engineers by Johnstone Wright on 26.10.1939 pub. Journal of Inst. Elec. Eng. January 1940 Vol. 86 page 10.

18. Journal of Inst. Elec. Eng. January 1940 op. cit.

19. Electrical Transmission, D.F. Sayers, pub. Journal Institute of Fuel May 1960 Vol. 33 No. 232 Page 249.

20. The Design and Operation of the Grid System of England and Wales by Clark, Littler and Scott. Sixth World Power Conference Melbourne 20th October, 1962. Diagram No. 3 is based on Figure 3 page 1938.

21. Britains 275 kV Grid System pub. Times Review of Industry September 1952, page 28.

22. Planning New Works pub. C.E.G.B. page 1.

23. Select Committee on Nationalised Industries H.M.S.O. Vol. 1 para. 434.

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PART TWO: OVERHEAD LINES AND UNDERGROUND CABLES

CHAPTER FOUR

Routeing of Overhead Lines

4.1 Introduction

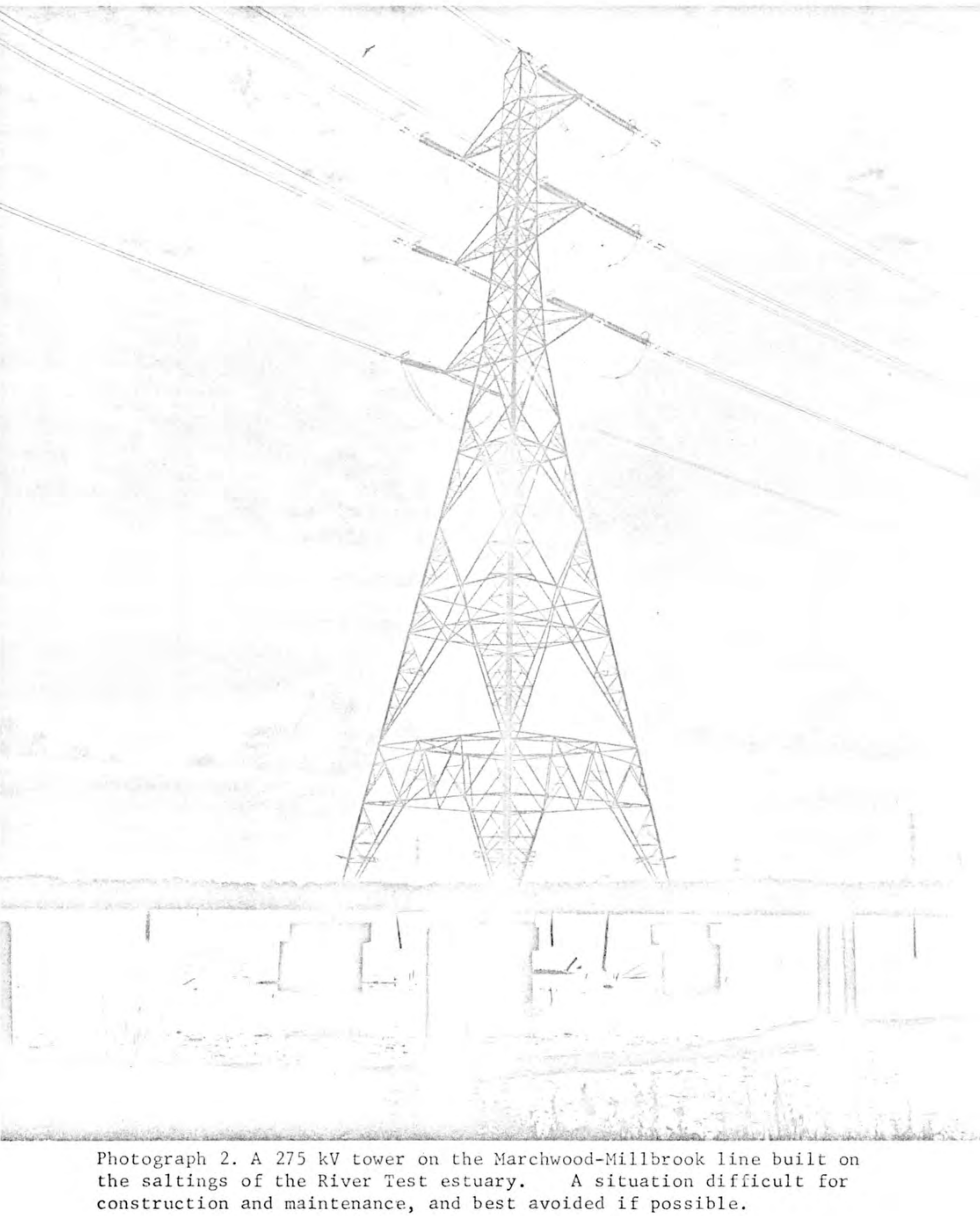
The engineering requirements, and considerations of amenity, are the two easily distinguishable aspects of overhead line routeing, and it is proposed to examine in detail the various factors involved in both of them. The route of the line depends largely on matters outside engineering design, and consequently it becomes necessary to reconcile overall planning demands, suggestions and opinions with engineering costs and efficiency. The responsibility for establishing the route of a line is that of the Wayleave Officer, but ideally the task is best carried out jointly between Engineers and Wayleave Officers, so that a satisfactory compromise may be achieved between the best amenity and engineering routes. It is proposed first to consider the engineering requirements of a transmission line, and then to examine how far these may require modification to take account of visual amenity.

4.2 Engineering Considerations

The engineering considerations which influence the choice of overhead lines are founded on two basic requirements. Firstly, that the line should be constructed at the lowest possible cost, and secondly, that the line should be capable at all times of carrying efficiently the electrical loads requiring transmission. These requirements are related to the apparently simple problem of obtaining the shortest distance between two substations, but the Engineer and Wayleave Officer will have many considerations in mind that will of necessity deflect them from the shortest route. Many of these considerations and problems arise directly from the physical geography of the area. One of these is to consider the bearing quality of the ground for the tower foundations, whilst at the same time trying to avoid good quality farmland. The Board has demonstrated its ability to build towers on any quality land even on marsh and peat bogs although this would not be done if a reasonable alternative was available. To construct a tower on bog would require piled foundations involving extra cost of between £1,200 and £6,000. In addition to this cost there is a greater possibility of severe disturbance to the adjoining ground caused by the process of building the tower. The Engineers have to be constantly aware of the dangers of subsidence in mining areas, and if such areas cannot be avoided a special foundation construction is adopted. It is thought that the Board would be unlikely to purchase an area of the underlying mine to be specifically preserved from mining in order to assure support for the tower. The economics of this situation seem to suggest that because of the hundreds of towers involved, and the large quantity of coal that would be sterilised, it would be cheaper to replace those few towers that become seriously affected by ground settlement.

In observing the position of towers on undulating ground there seems to be a preference for angle towers to be sited in hollows, and the straight line towers on brows of hills. This is apparently done for an engineering reason as a more economical tower is possible under these circumstances.

The Board prefers to avoid routing a line across high ground over 1,000 ft. above ordnance datum because of the danger of icing on the towers and conductors, which may under severe conditions cause them to break. Photographs No. 3 & 4 show examples of the effects of bad winter



Photograph 2. A 275 kV tower on the Marchwood-Millbrook line built on the saltings of the River Test estuary.   A situation difficult for construction and maintenance, and best avoided if possible.

Photograph 3. Broken conductors on a 132 kV line in South Wales caused by snow and high winds during the winter of 1963. The difficulty of repairing lines under these conditions suggests that lower and more sheltered routes for transmission lines should be chosen if possible.

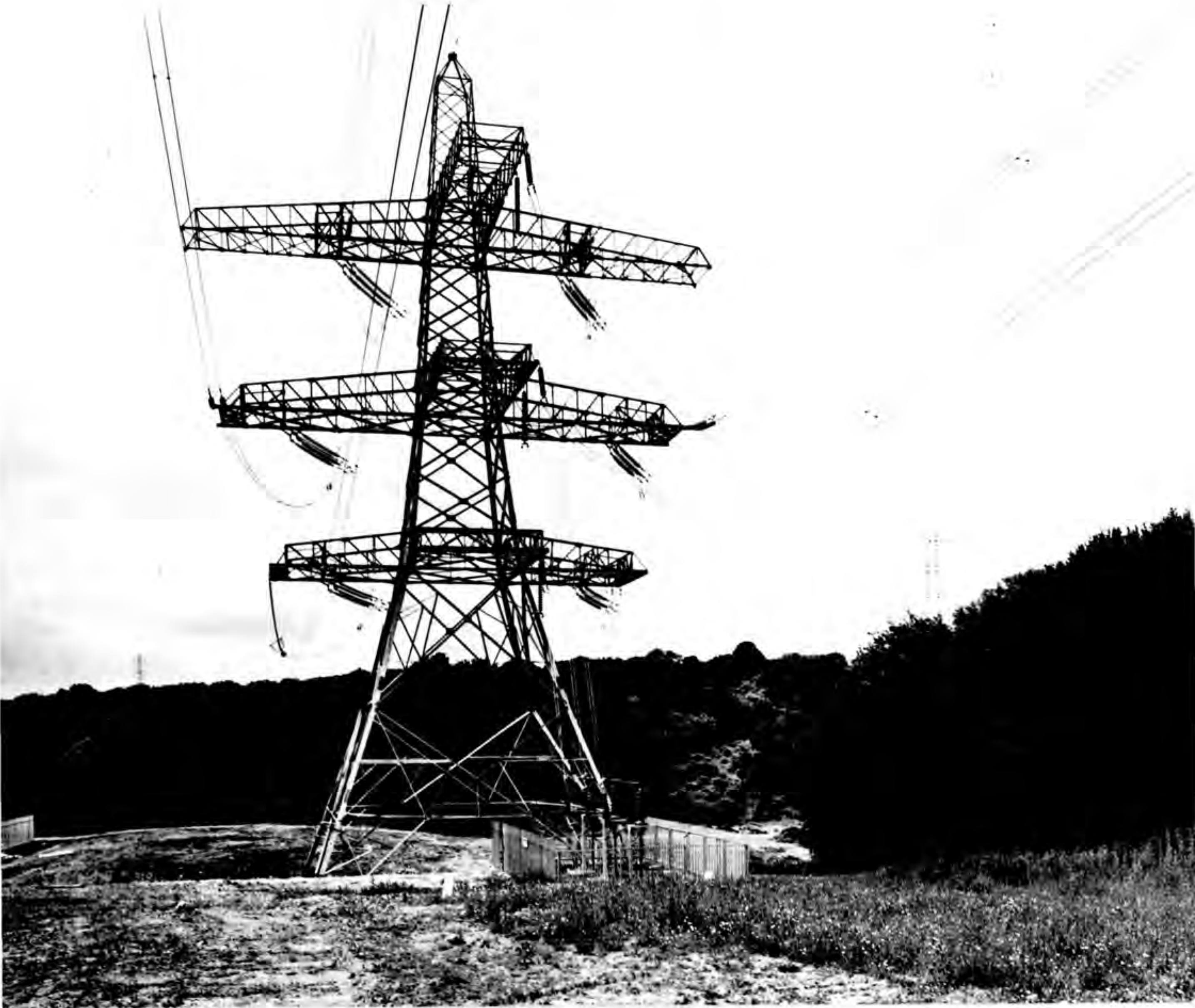
Photograph 4. Icing on the Uskmouth to Crumlin Llantarnam 132 kV line.

weather which is aggravated under such conditions. In such situations the line becomes more vulnerable to strikes of lightning and freak high winds. It may be necessary to reduce the distance between towers over particularly high and exposed areas in order to reduce these hazards. Undulating ground does not normally present a problem, but siting towers on a steep slope would increase the cost of foundations, and also the height of the tower, this increase in height is required to ensure that a statutory minimum distance is maintained between the conductor and sloping ground when the conductor is blown towards it.

Vehicular access is required to all tower positions both for construction and subsequent maintenance of the line, and the engineer will always have in mind the costs if extended access roads have to be built across wild and remote country, or if special transport equipment becomes necessary.

A considerable tonnage of steel and concrete is involved in the construction of a tower. In the case of 400kV straight line tower it would be approximately 82 tons. This tonnage is increased six fold for an angle tower, and for a 400kV terminal tower 660 tons of material are required. From this follows a preference to build angle towers near to a highway for easy access. Unfortunately such positions tend to make these larger and bulkier towers even more obvious to the public. Easy access to tower sites is not only important for construction and maintenance, but particularly when faults occur which are more likely under adverse winter conditions, when tower sites may become inaccessible due to flooding.

The Engineer for reasons of economy will plan the route to be



Photograph 5. An angle tower at Ninfield substation, East Sussex on the Lydd-Bolney 400 kV line. One circuit drops down to the sealing end compound, and is cabled into the substation, (just left of the photograph) and the other circuit bypasses the substation.

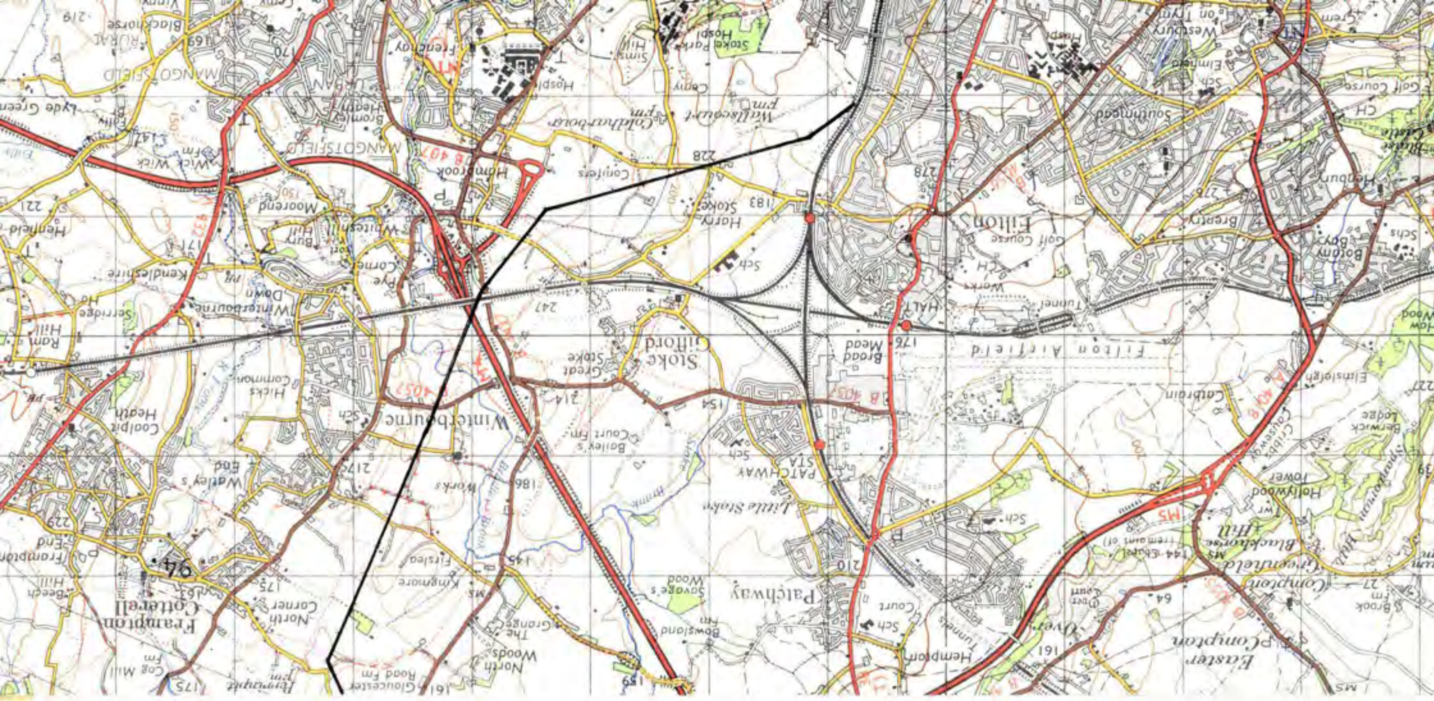
as straight as possible (1), but where changes of direction become necessary he attempts to keep each section as long as possible in order to reduce the number of angle towers. An angle tower costs approximately £5,000 more than a straight line tower because of the larger foundations, increased weight of steelwork, and the increased number of insulators. The Engineer endeavours to keep each straight length of line a multiple of the basic span, which in the case of 400kV line is 1,200 ft. between towers (2). The most economical line will therefore have sections of 2,400, 3,600, 4,800 ft. etc. up to two and half to three miles, which is the recommended maximum length of one section.

All of these purely engineering considerations interact to varying degrees of advantage or disadvantage on many practical amenity and administrative matters. The Wayleave Officer has to modify the optimum engineering solution because of many of these other factors. For instance he will support the Engineers' wish to keep the number of angle towers to a minimum, and the angle of deviation as small as possible, because not only are angle towers more expensive than straight line towers but they are larger, more obtrusive, and give rise to greater amenity objection. When angle towers do occur he will attempt to site them straddling a fence, hedge or ditch to create the least obstruction to the use of the land, but this procedure may need to be modified by local requirements and custom. If an angle tower can be sited near a road for ease of access it can also help to reduce appreciable the amount of damage to land, as well as reducing the construction effort.

It is preferable to avoid crossing motorways, as the Ministry of Transport is usually reluctant to allow them to be closed whilst the line is being strung. In order to prevent interruption of motorway traffic it becomes necessary to construct scaffolding across the full width, and it is therefore more economical if such a crossing can be made as near to a right angle to the road as possible. A recent example of this is shown on photograph 6 where a crossing the the M.4 was required. This would seem to be an expensive as well as hazardous operation and one would have thought that closing the motorway for a brief period of say 20 minutes at a time when the motorway is carrying the minimum traffic would have been a practicable as well as economic proposition. A similar but less onerous problem arises with the crossing of railways, waterways, and canals. The Board also tries to avoid crossing houses and gardens, because of the difficulties of scaffolding, and possibility of damage to private property, as well as the objection of the owners of the property affected.

The Wayleave Officer in making his preliminary reconnaissance for a route will particularly note the location of airfields. The Ministry of Defence safeguards the flight paths of Service Airfields, or those which may be required in an emergency; similarly civil airfields are safeguarded by the Board of Trade by ensuring that no buildings or structures exceed a prescribed height for given surrounding areas. With considerable number of airfields in this country it is not surprising that almost every major route has a diversion to avoid an airfield. In the case of London Airport it became necessary to put underground a short section of line where it crossed the flight path, and in at least three other cases at Lydd, (3) and Filton and Biggin Hill Airfields the Board was obliged to design special low height towers in order to meet requirements which would endanger aircraft.

Associated with airfields are many V.H.F. and homing beacons, of whom the operation must not be jeopardised. The Ministry of Defence is



Map 14. Showing part of the route of the Iron Acton-Locklease 400 kV line and the position where it crosses the M.4 motorway at Hambrook near Bristol.

Photograph 6. Showing the extensive scaffolding required to support conductors during construction across the M.4 motorway.

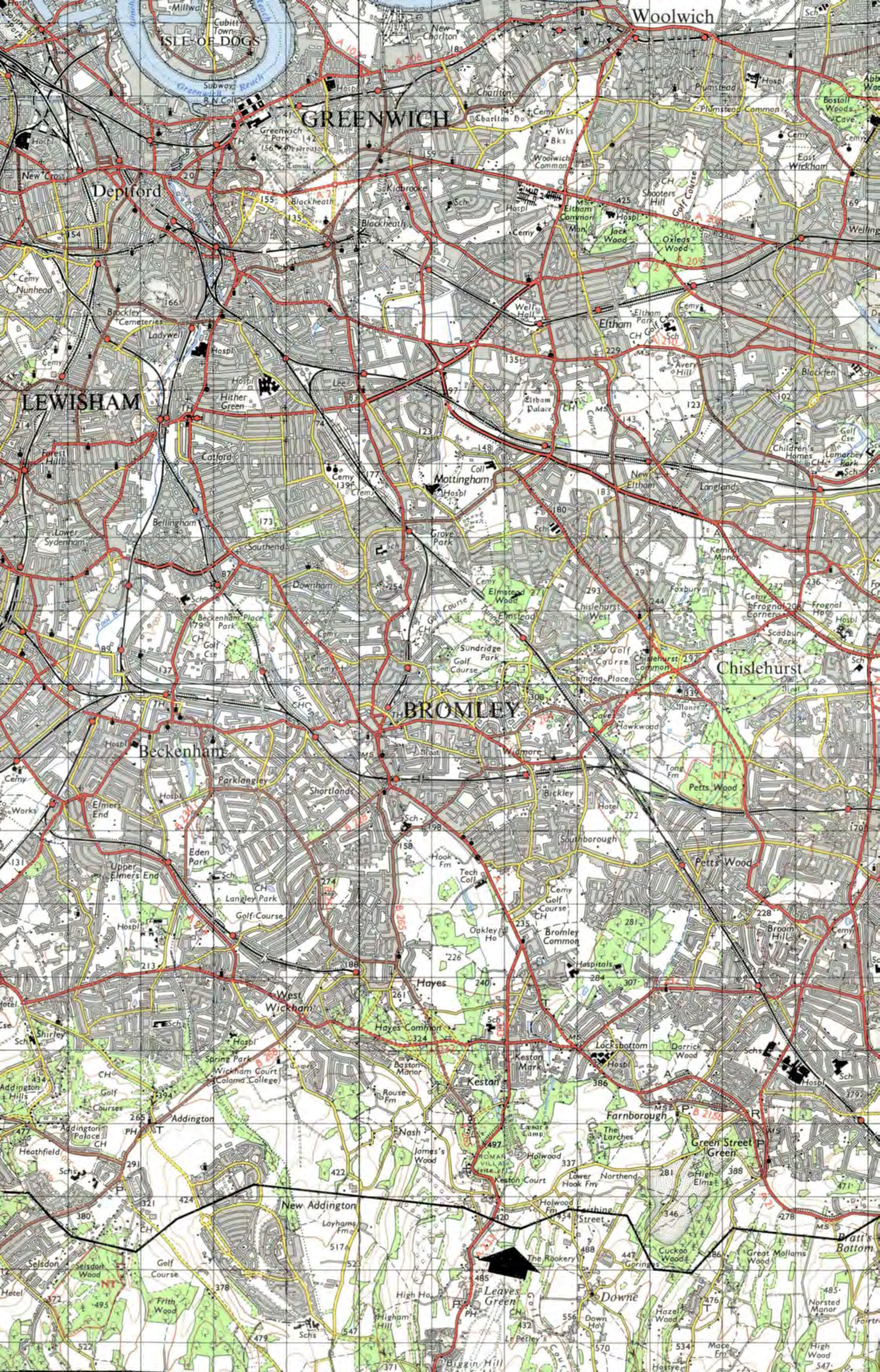
Photograph 7. Reduced height towers on Iron Acton-Locklease 400 kV line crossing M.4 motorway at Hambrook to provide safety clearance for aircraft using Filton airfield.

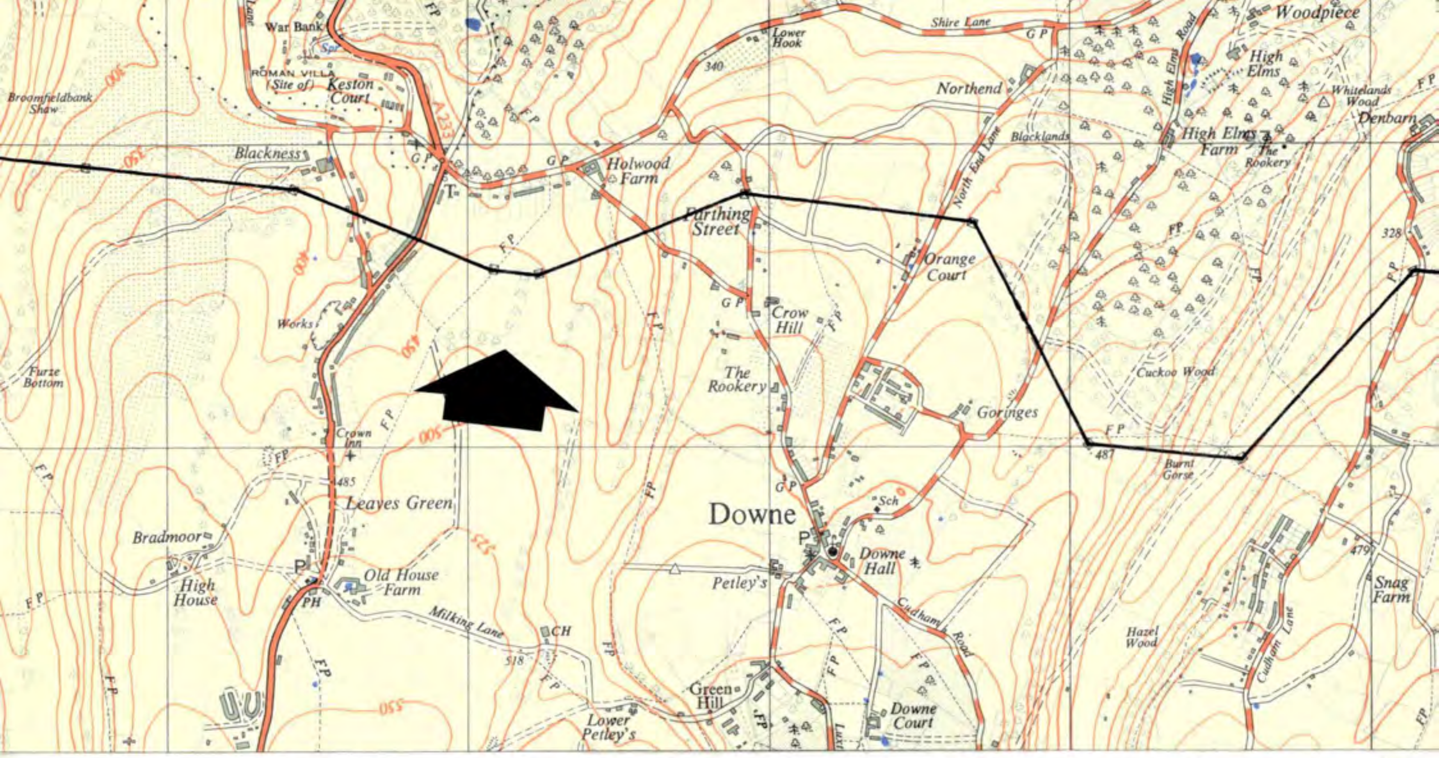
MAP 15 REDUCED HEIGHT TOWERS TO PROVIDE SAFETY CLEARANCE FOR AIRCRAFT APPROACHING OR LEAVING THE MAIN RUNWAY OF LYDD AIRPORT

PHOTOGRAPH 8 REDUCED HEIGHT TOWERS CLOSE TOGETHER WITH TENSION INSULATORS. NOTE STANDARD HEIGHT TOWERS TO RIGHT OF PHOTOGRAPH.

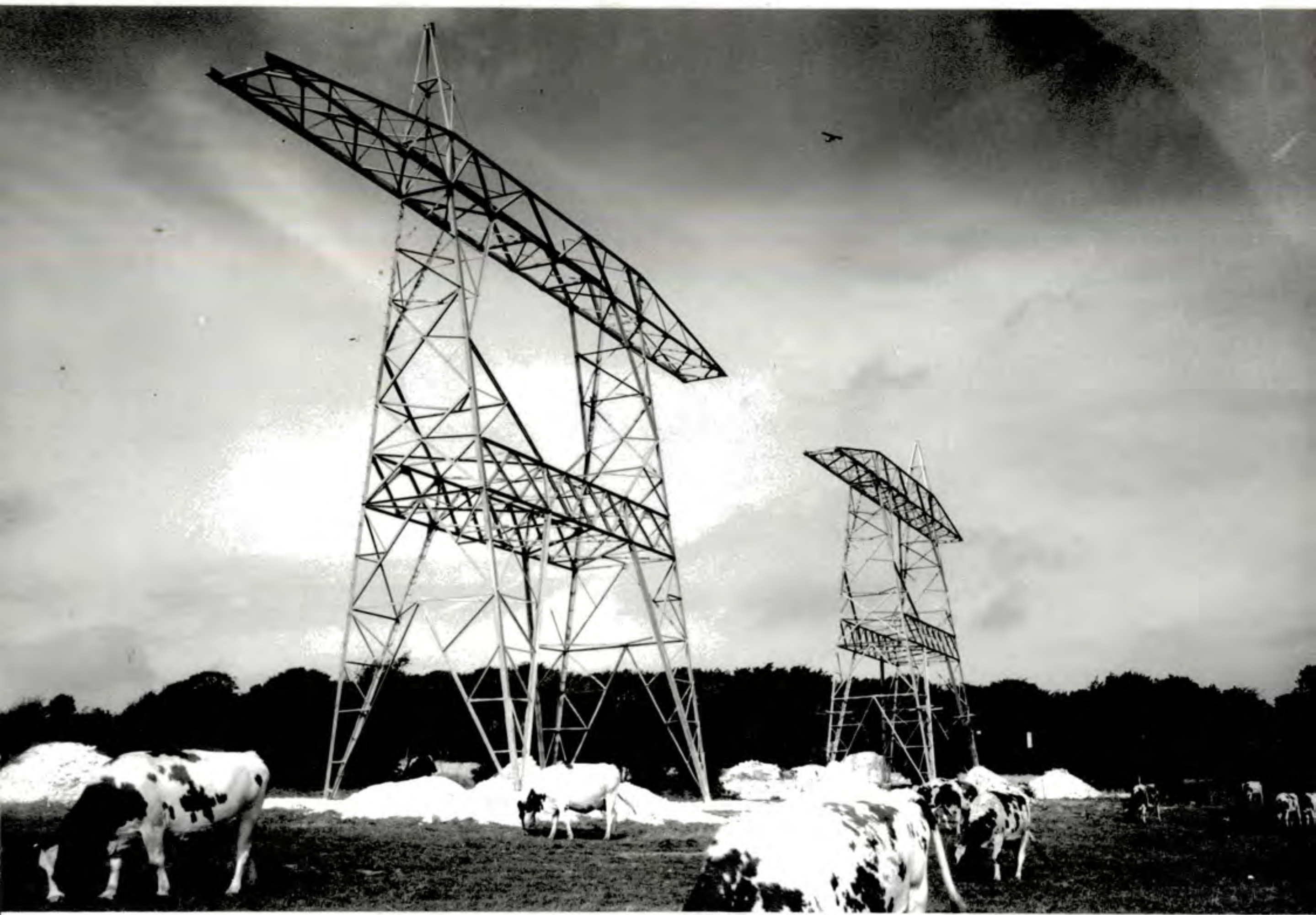
Please turn over for:-

Map 16. Showing part of the Northfleet - Addington 275 kV line which passes within half a mile of the northern end of Biggin Hill airfield in Kent.


Woolwich
ISLE OF DOGS
Millwall
Cubitt Town
New Charlton
GREENWICH
Charlton
Plumstead
Plumstead Common
Greenwich Park
Deptford
New Cross
Blackheath
Kidbrooke
Woolwich Common
Shooters Hill
Eltham Common
Jack Wood
Oxleas Wood
East Wickham
Welling
Nunhead
Brockley Cemeteries
Ladywell
Well Hall
Eltham
Avery Hill
Blackfen
LEWISHAM
Hither Green
Lee
Eltham Palace
Forest Hill
Catford
Mottingham
New Eltham
Lamorbey Park
Langlands
Grove Park
Lower Sydenham
Bellingham
Southend
Downham
Elmstead Wood
Elmstead
Chislehurst West
Foxbury
Frognal Corner
Scadbury Park
Beckenham Place Park
Sundridge Park
Chislehurst Common
Chislehurst
Camden Place
BROMLEY
Hawkwood
Beckenham
Widmore
Parklangley
Shortlands
Petts Wood
Elmers End
Bickley
Southborough
Eden Park
Upper Elmers End
Langley Park
Golf Course
Hook Fm
Tech Coll
Bromley Common
Oakley Ho
Broom Hill
Hayes
West Wickham
Hayes Common
Shirley
Spring Park
Wickham Court (Coloma College)
Boston Manor
Keston
Keston Mark
Locksbottom
Darrick Wood
Addington Hills
Addington
Rouse Fm
Farnborough
Addington Palace
Nash
Caesar's Camp
Holwood
Green Street Green
Heathfield
James's Wood
Keston Court
Lower Hook Fm
Northend
High Elms
New Addington
Holwood Fm
Farthing Street
Pratt's Bottom
Selsdon
Selsdon Wood
The Rookery
Cuckoo Wood
Great Mollams Wood
Frith Wood
High Ho
Leaves Green
Downe
Down Ho
Hoze Wood
Norsted Manor
Highams Hill
Le Petley
Mace Fm
High Wood
Biggin Hill



Map 17. Showing part of the Northfleet-Addington 275 kV line north of the main runway of Biggin Hill airfield.



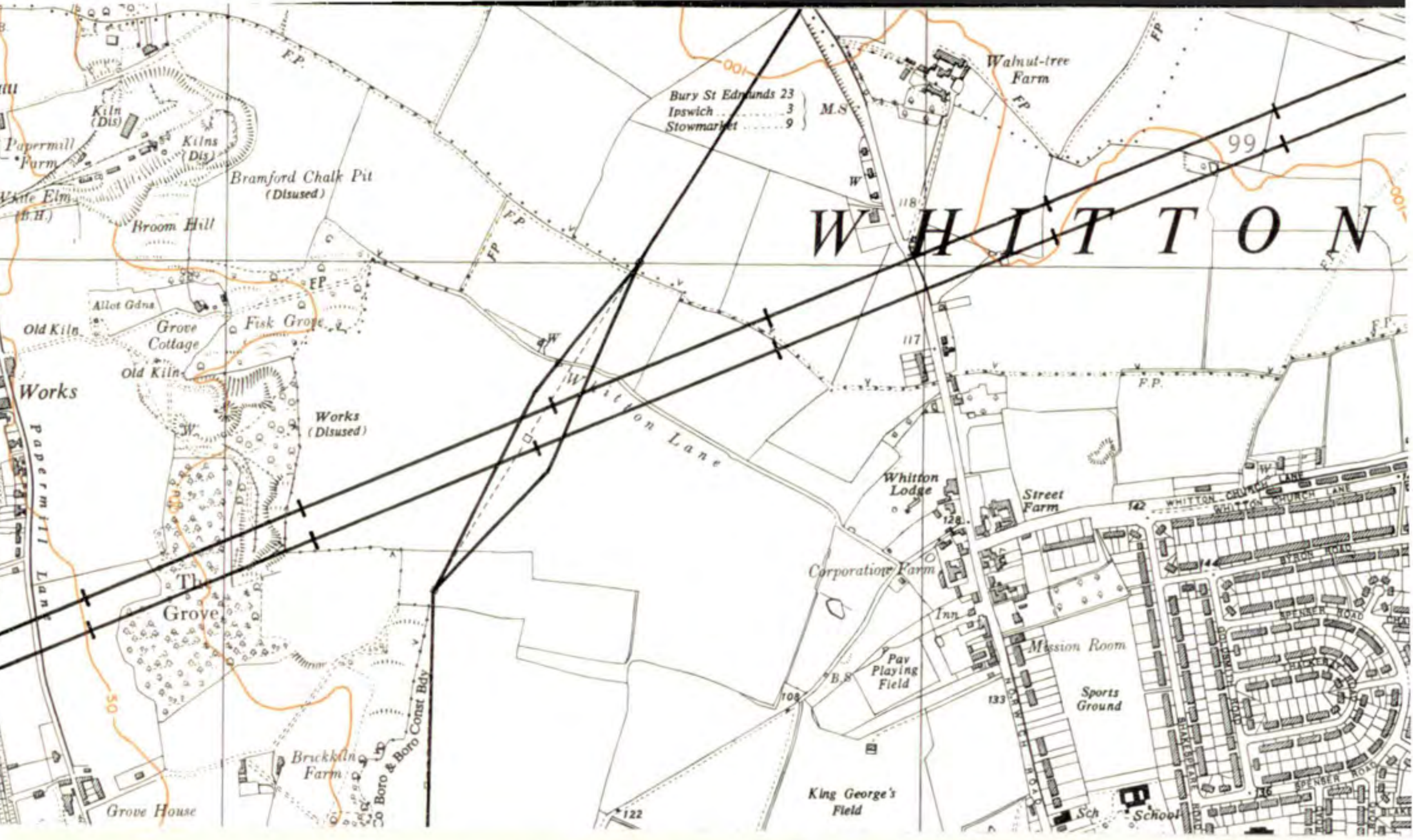
Photograph 9. These special towers were designed in order to provide a safety height limit to aircraft using Biggin Hill airfield. A normal 275 kV tower is 136 ft. high carrying two circuits in vertical alignment, but in this instance each circuit is carried separately in horizontal arrangement on its own gantry, which has reduced the height to 70 ft. This has achieved an overall reduction of 66 ft., but is not regarded as a visually elegant solution to the problem.

responsible for the many sites of radar stations and ensures that towers do not obstruct the "scanning field" of the apparatus. Similarly the Admiralty are responsible for certain installations and require to be consulted. The whole of the coast and most tidal waters come under the jurisdiction of the Admiralty, the Board of Trade and various harbour, navigation and dock authorities, who ensure that coast defences and navigation are not prejudiced. There are also certain safeguarding restrictions around some G.P.O. installations including direct beam television and telephone channels.

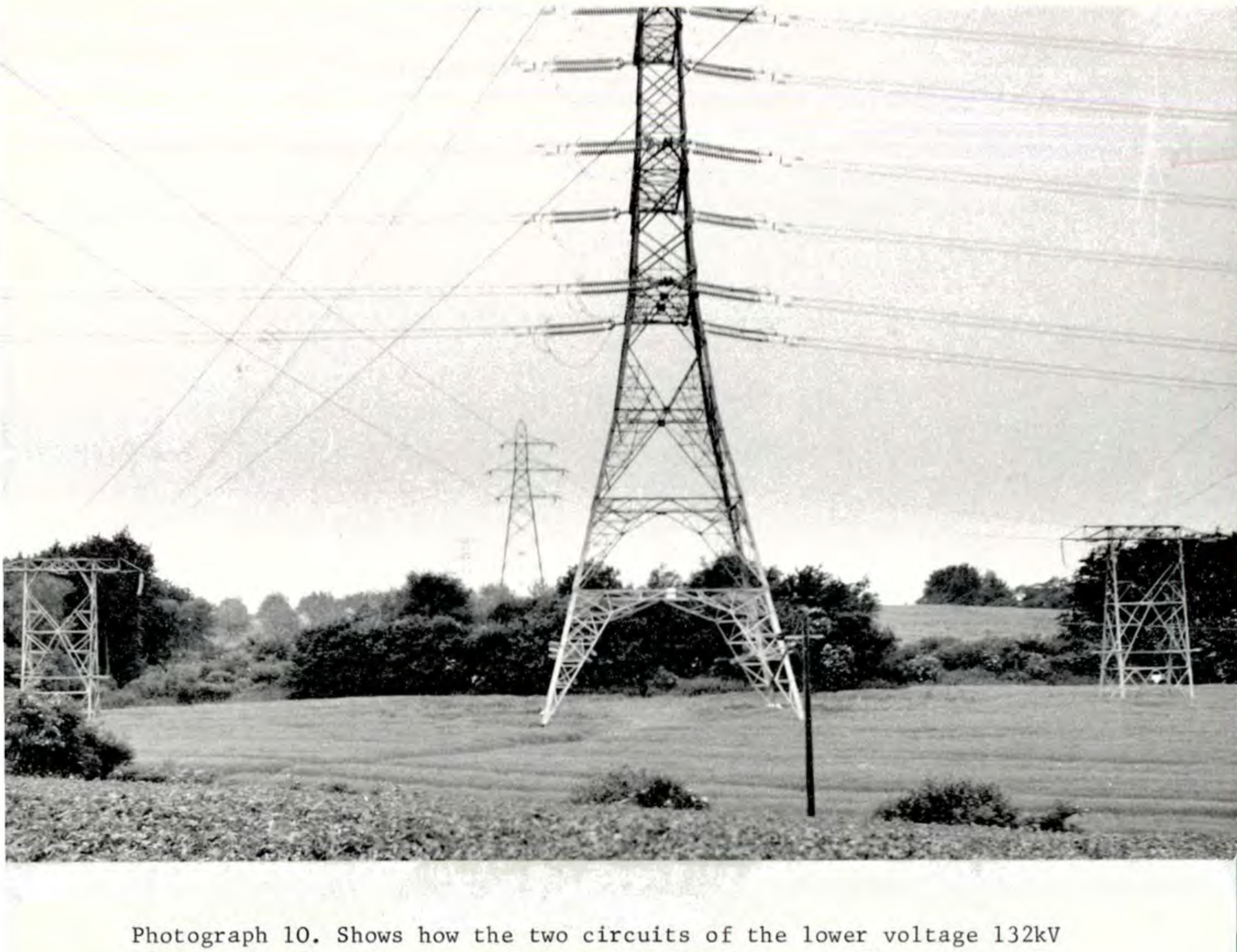
If it is reasonably possible the Board prefers to avoid the crossing of two overhead line routes. In order to maintain the minimum electrical clearance between conductors the crossing of lines has to be arranged by lowering one line by using gantries instead of towers, or alternatively lifting one line over the other on higher towers. Both methods appear clumsy and add to the cost of construction.

There is a possibility that if an overhead line should run parallel to a railway or trunk post office line, induced currents may cause some interference (4). The Board usually offers to pay for the undergrounding of such lines to avoid any chance of this happening, if it should not be possible to route the Board's line in any other direction. Apparently the nearer to a right angle crossing of lines the less chance there is of electric currents being induced that would cause telephone, radio or television interference.

Having established a general route for a line that is likely to receive the consent of the Ministry of Power a line profile is prepared by the Board from which the most economical arrangement of towers is



Map 18. Showing the position of the crossing of the Sizewell-Bramford 400 kV line with the Bramford-Stowmarket 132 kV line near Whitton, Suffolk, illustrated below.



Photograph 10. Shows how the two circuits of the lower voltage 132kV line are split and carried on gantries situated on either side of the 400kV tower, known as a 'diamond crossing'.

calculated. It is at this stage that consideration is first claimed to be given to the wishes of the landowner. If the length of a section approximates to a multiple of the basic span, then with use of tower extensions, movement of intermediate towers along the line is normally possible. For example, assuming satisfactory ground contours and using tower extensions, the sum of the adjacent spans can be increased to 2,640 ft. and an individual span increased to 1,800 ft. The Board's Engineer, h having learnt of any specific wayleave requirements, will try and fix the towers in a section so that the most economical use of extensions is obtained, keeping the spans in any section as even as possible, and avoiding using very high extensions. Flexibility of tower positions will usually be possible by using extensions. The Board usually obtains an aerial survey for long lines. The advantages are mainly speed, but the fact that ground survey consent is not required means that tower positions, or alternative route profiles can be obtained without having to make repeated ground surveys across agricultural land.

Every time a proposed route is amended it will require an engineering assessment involving most of the factors that have so far been mentioned. The cost and trouble of such an assessment is no doubt a material consideration why the Board sometimes seems to show a reluctance to seriously consider alternative routes.

4.3 Amenity Aspects

Having considered the engineering factors involved in planning the route for an overhead line, it now becomes necessary to examine how the optinum engineering solution may become modified from the consideration of visual amenity. This is the aspect of the job which causes the greatest concern from the point of view of the public. The general question of amenity and the Board's Policy will be discussed later but at this stage it is proposed to examine what the Board says and more importantly what it does concerning the amenity aspects of overhead lines.

From their experience the Board's Wayleave Officers, when plotting a route will know what sections of the line will cause the greatest amenity offence, and by anticipating it, it might be suggested that they will do their best to mitigate it effect within their own terms of reference. The Wayleave Officer should have obtained information on any protected land designated a National Park (5), Area of Outstanding Natural Beauty, Nature Conservancy Area, National Trust Property, Green Belt, as well as the location of any Ancient Monuments, and Historic Buildings, and by being aware of them would endeavour to avoid them.

In 1959, the first of the 275kV supergrid lines were being built, and it was this development which chiefly stimulated a public awareness of the visual effects of these towers and lines on the countryside. This awareness resulted in a hardening of the public and Local Authorities' attitude to the idea of supergrid lines, which made the Wayleave Officers encounter more opposition in their regular work. The Board were concerned that the difficulties might prejudice the construction of the supergrid, and accordingly the amenity aspects of line routeing were frequently discussed at Board Members' meetings, when a policy decision was required on specific problems. At the time of nationalization of the industry the Minister of Power recognised that the Board in order to meet its statutory obligation to have due regard to amenity would require expert advice. For this purpose Lord Holford was appointed a part-time member of the Board. Both Sir Christopher Hinton, the Board Chairman, and Lord Holford spent much of their time considering this problem of overhead line routeing, Sir Christopher Hinton is reported as saying that he spent more time thinking about amenity than any other single problem. The Board doubtless felt obliged to give some amenity advice to their Wayleave Officers for guidance when considering a route for an overhead line. In November 1959 Lord Holford read a paper to the Royal Society of Arts (6) on the subject of preserving amenities in which he put forward seven rules as a general guide to Wayleave Officers in selecting routes for overhead transmission lines. The Board has said that nearly ten years' experience of the "Holford Rules" has confirmed that they are still as valid today as when they were first proposed. Because they are still said to be so important it is worthwhile quoting them in full:-

The Holford Rules:

"1. Avoid altogether, if possible, the major areas of highest amenity value, by so planning the general route of the line in the first place, even if the total mileage is somewhat increased in consequence;

2. Avoid smaller areas of high amenity value, or scientific interest, by deviation; provided that this can be done without using too many angle towers, i.e. the more massive structures which are used when lines change direction;

3. Other things, being equal, choose the most direct line, with no sharp changes of direction and thus with fewer angle towers;

4. Choose tree and hill backgrounds in preference to sky backgrounds wherever possible; and when the line has to cross a ridge, secure this opaque background as long as possible and cross obliquely when a dip in the ridge provides an opportunity. Where it does not cross directly, preferably between belts of trees;

5. Prefer moderately open valleys with woods, where the apparent height of towers will be reduced, and the views of the line will be broken by trees;

6. In country which is flat and sparsely planted, keep the high voltage lines as far as possible independent of smaller lines converging routes, distribution poles, and other masts, wires and cables, so as to avoid a concatenation or "wirescape";

7. Approach urban areas through industrial zones, where they exist; and when pleasant residential and recreational land intervenes between the approach line and the substation, go

> carefully into the comparative costs of undergrounding, for lines other than those of the highest voltage."

Lord Holford emphasised that these were only general principles, and that every situation should be judged on its merits, he went on to say:

> "the effect of rarity is nearly always to quicken the emotional content of any particular form of beauty and enhance its value."

The Board says that their Wayleave Officers are trained to keep a keen eye open for the "rarities", whether they be unique views or panoramas, areas of "transcendent" natural beauty, or "the only bit of green space for miles around". They are also expected to anticipate the reasonable requests of property owners, e.g. the line should not pass in front of houses if there is an equally acceptable route to the rear or "blind" side of them. Similarly they should not route a line across first class arable land, if a reasonable route was available across land of lower quality. It is obvious that an overhead line cannot be routed until the two points of termination have been settled, but the selection of substation sites is governed to some extent by the effect of the line entries. It is usual therefore for the investigation of both to be carried out concurrently, but this is a delicate central issue discussed more fully in the case studies which follow.

On the basis of all this information and with an intimate knowledge of the area through which the line is to be routed, the Wayleave Officer would be expected to adjust the straight line route to suit the special features of the district through which it passes. A map at a scale of 1" to 1 mile is often used for this preliminary plotting. The Board then usually makes an informal approach to the Planning Authority, and with all Local Authorities who will be affected. This can result in meetings with officials, sub-committees, committees, and possibly with the Full Councils or in joint meetings with various neighbouring Councils. Proposed amendments or objections are discussed and a solution, usually a compromise, is sought. This aspect is elaborated in chapter seven of this work, which deals with the negotiations for consent for a specific line.

4.4 A Mathematical Method of Line Routeing

The routeing of overhead lines would seem to be determined by the varying importance attributed to these engineering and amenity factors and for the intuitive feeling and local knowledge of the Wayleave Officer. One may ask whether the routeing of a line could not be dealt with as a mathematical exercise, but frequently such an approach is abandoned when an attempt is made to quantify visual amenity and natural beauty.

There was however one instance when a mathematical solution to a routeing problem was proposed. This was advanced during the course of a public inquiry at Lewes into the Lydd to Bolney 400kV Line (7). This method recognised that the main objection to any particular route was likely to come from those people who wished to preserve the beauty of the countryside. To discover the best amenity route they attempted to devise a method of measurement of the overall obtrusiveness of a line and to develop a technique for computing which route minimised the obtrusiveness. A formula was devised which quantified nuisance, and extended it to enhance a segment of overhead line. A graphical method was also propounded which plotted heights above ordnance datum at a half inch grid on a 1" to 1 mile map and a line sought which joined the lowest points.

Acting for objectors the firm (8) that developed those mathematical techniques produced a tentative alternative route and wrote to Sir

Christopher Hinton the Chairman of the C.E.G.B. suggesting that he might sponsor a comprehensive study of the method they had evolved.

Sir Christopher rejected this suggestion on the grounds that people would resent the use of computers as being a seemingly mechanical solution to a human problem. He believed that in routeing lines detailed consideration must be given to many factors which could only be judged by the human eye; studies of the sort suggested, but on a more elaborate scale, might determine the merits of alternative line routes, but the end-product would never be more than an elaborate way of stating what must always remain a matter of individual judgement. Sir Christopher said that the studies would be very time-consuming, and he thought it unlikely that they would be an unassailable answer to the Board's critics, or that they would minimise delay and dispute in securing approval for the Board's plans. On the contrary, some critics would say truthfully that they could be no more accurate than the human judgements upon which they must be based. Sir Christopher thought that the techniques in current use were the best available.

These comments by Sir Christopher made at a time when the Board was being embarrassed by the number and duration of overhead line public inquiries, particularly the one at which this suggestion was made which went on for six weeks, now seem to have been influenced by political and perhaps organisational factors rather than by a scientific and objective assessment of the method.

Mr. R.E. Hammerton an objector at this inquiry commented that in a case where at some stage an initial line has to be evolved it could be done much more efficiently by way of computation than by the well-meaning but hit-and-miss method of one or other of the Board's officials tramping across the countryside and using his own feelings and views as the basis of a tentative line. It is to be hoped that these words of Mr. Hammerton will be remembered by the Board, and that they will be prepared to undertake such a mathematical study, particularly now that improved techniques would be possible because of the facility afforded by the more extensive use of computors.

4.5 Conclusion

It will be appreciated that there is no quick and easy answer to the problem of routeing overhead transmission lines, and it represents a remarkable achievement of engineering and negotiation to obtain the consent for a line without an objection being pressed to a Public Inquiry. Because of all these sometimes conflicting interests which cannot be fully reconciled there is an increasing tendency for every major line to be subjected to the procedure of a Public Inquiry. In order to illustrate some of the various factors involved and the influence they exert it is proposed to examine in some detail in a later chapter, the routeing of approximately 35 miles of 400kV overhead line across the Pennines between Bradford in Yorkshire to Darwen in Lancashire.

CHAPTER FOUR

References

1. The cost of a 400 kV overhead line is £65,000 a mile, every extra yard increases the cost by about £37. Span. March 1965.

2. In the case of 275 kV line the optinum span length is 1,200 ft. and for 132 kV is 1,000 ft.

3. On the short length of line between Dungeness Nuclear Power Station and Lydd Substation it became necessary for a distance of about three quarters of a mile to keep the tower height down to about 110 ft. Nine standard 400 kV towers were used with the peaks removed and without the bottom two lattice bays. The towers were also placed much nearer together being only about 150 yds apart, and the conductors were strung with tension insulators instead of suspension insulators in order to reduce the sag of the conductors.

4. Hansard. House of Commons, 20.12.66 Vol. 738 Col. 240.

5. This early and informal consúltation with the National Parks Commission on the routeing of overhead lines through National Parks and Areas of Outstanding Natural Beauty was agreed in about 1955. Sixth Report National Parks Commission, 1955. Page 21.

6. Power Production and Transmission in the Gountryside. Preserving Amenities. Sir Christopher Hinton, Chairman C.E.G.B. and Sir William Holford, C.E.G.B. part-time member. Two papers read to the Royal Society of Arts on Wednesday, 25th November, 1959 Published R.S.A. Journal December 1959. Volume 108 p.p. 180 - 200 Reprinted by C.E.G.B. 1960. This is considered to be one of the best statements of C.E.G.B. Amenity Policy.

7. The Inquiry was held from 31.10.61 to 8.12.61, and this mathematical method was mentioned in the Estates Gazette 1.8.64.

8. The firm was called S.I.G.M.A. - Science in General Management - One of the objectors to the Lydd to Bolney line was a director of this firm.

CHAPTER FIVE

Transmission Lines. Their Effect on the Land

5.1 Introduction

The Generating Board has nearly 9,000 miles of overhead line on about 51,000 steel lattice transmission towers (1) which occupy a total area of just under 400 acres, or to put it another way there is about one tower for every 745 acres of England and Wales (2). At first it would seem that the effect of overhead lines on land would be modest enough but on closer examination it will be seen that a line can have a considerable effect over many aspects of land use.

The owner of land is owner not only of the surface of it, but of the air and space above it, and of the minerals beneath it. (3) He can deny and restrain any person who attempts to invade his right or interest in his land without lawful authority. This chapter examines briefly the statutory powers the Board possesses to enable it to erect overhead lines, and the resultant effects a line may have when built over agricultural land, woodlands and buildings.

5.2 Statutory Powers to Construct an Overhead Line

When the Board wishes to erect a tower it requires an easement over the land. The legal definition of an easement is, "a privilege without a profit", it is a right attached to one particular piece of land which allows the owner of that land either to use the land of another person in a particular manner, or to restrict its use by that other person to a particular extent. An easement confers upon its owner no proprietary or possessing right in the land affected. It merely imposes a definite and limited restriction upon the propietary rights of the owner of the land.

Whenever the Board pays a capital sum representing depreciation to a property due to a grid line they also require in return the grant of a permanent easement for the line. If the easement were not permanent other claims for depreciation could be made against the Board, and the same claim for which they had already paid could be made by a new owner if the property changed hands.

Normally the Board gets security to tenure for the line in perpetuity, but there have been very few cases where the owners would grant an easement for only a limited time such as 21 years.

The Board can construct lines above ground only with the express consent of the Minister of Power. When the Minister has consented to the Board's proposal to place an overhead line, the Board is still obliged to obtain wayleave agreements with the owners of the land along the proposed route. There is nothing to prevent the Board from negotiating wayleave agreements before the Minister's consent has been given. The Board usually endeavours to obtain as many wayleaves as possible before applying for consent for the line, as the Minister's attitude towards the application at this stage is largely determined by the degree of co-operation or otherwise, shown by the landowners affected.

Under the earlier electricity Acts the Minister's consent to the proposed line had to be obtained first, and wayleave agreements negotiated only after that consent had been obtained, but amendments made to the Electricity (Supply) Act, 1926 provide that both these steps may be made concurrently. (4)

When the Board has obtained the Minister's consent to the placing of an overhead line over privately owned land, the Board must tell both the owner and occupier of the land of its intention and give them details of the towers and lines it wishes to erect. If an owner or occupier is unwilling to enter voluntary into a wayleave agreement the Board has powers (5) to obtain a compulsory wayleave.

The possibility of a landowner's objection being prejudiced by the Minister's consent to a line was recognised at the time the Electricity Act, 1957 was going through Parliament. It was due principally to the representations of the Country Landowners Association that the Act made specific provision to ensure that objections to wayleaves were not prejudiced. (6) When the Board makes application to the Minister for the placing of a line and it is stated that not all of the wayleaves have been agreed, the Minister may nevertheless give his consent to the line, subject to the condition that the actual work of erecting it shall not proceed without his further permission. This provision attempts to meet the criticism that an owner or occupier of land who objects to granting a wayleave is prejudiced in pursuing his objections if towers have already been erected on the land of a neighbour who has granted a wayleave voluntarily.

Despite this statutory provision the landowner objecting to a tower still often feels aggrieved, once the Minister has consented to a line, even if it does have conditions attached that it may not be built without further permission. It seems to an objector that the Minister has said that a line will follow a certain route, and is then asked to arbitrate in the matter of a tower position forming part of the route he has approved. It is hardly surprising that the objecting landowner is unlikely to have confidence in the impartiality of the Minister of Power.

5.3 Compensation

Every landowner having a tower on his land is entitled by statute to compensation:-

> "The undertakers shall cause as little detriment and inconvenience and do as little damage as may be, and shall make full compensation to all bodies and persons interested for all damage sustained by them by reason or in consequence of the exercise of such powers, the amount and application of such compensation in case of difference to be determined by arbitration".

The Minister of Power is not concerned with the question of compensation (8) thus an owner cannot sustain an objection to him, nor can the Minister impose a condition concerning the payment of compensation by the Board when he gives his consent. If the amount of compensation is disputed it may be referred to the Lands Tribunal. If the compensation refers to damage, or loss of crops during the course of the construction such claims may be referred to an arbitrator unless otherwise agreed between the landowner and the Board.

The detriment of an overhead line on different uses of land, and the grounds for a claim for compensation will be considered under the principal uses of land.

5.4 Effect on Agriculture

Immediately following nationalisation of the Industry consideration was given to the standardisation of the terms and conditions for Wayleaves in respect of privately owned property, and of property owned by Government Departments and other nationised Industries. Discussions were commenced with the Country Landowners Association and the National Farmers Union. In 1949 there were 50,000 separate wayleaves requiring 19,000 separate payments each year. (9)

In March 1965, (10) the C.E.G.B., the C.L.A. and the N.F.U. agreed that they should jointly investigate the working time lost and crop loss incurred under the mechanised condition of modern agriculture because of the presence of transmission towers, and that the scale of compensation payments should be adjusted appropriately. The joint investigation has been carried out, and the Board, the C.L.A. and the N.F.U. have agreed on revised compensation payments for interference with agricultural operations.

The basic scales of compensation are set out in full in Appendix 'D'. It will be seen that the compensation to the grantor of the wayleaves falls under two heads; firstly, an annual rental for each tower and secondly, compensation for the interference with the husbandry of the land in which the poles or towers are laid, and this in turn depends on whether the structures are erected on arable land or pasture. These payments are to cover the costs of keeping the site of the tower clean, or of avoiding it in the course of cultivation, to compensate for loss of profit in the area rendered unproductive, and for diminished yields on land immediately adjoining that area. The rates given are the revised rates settled in 1966 which took effect on and after 31st December, 1966, and will be in force for at least 3 years from that date.

The towers of the C.E.G.B.'s 400 kV lines have not been erected long enough for their effect on agricultural operations to be properly appraised, so it has been agreed that payments for towers with base dimensions of 30 ft. x 30 ft., and above, shall for the present remain unaltered, but will be subject to review in the light of experience.

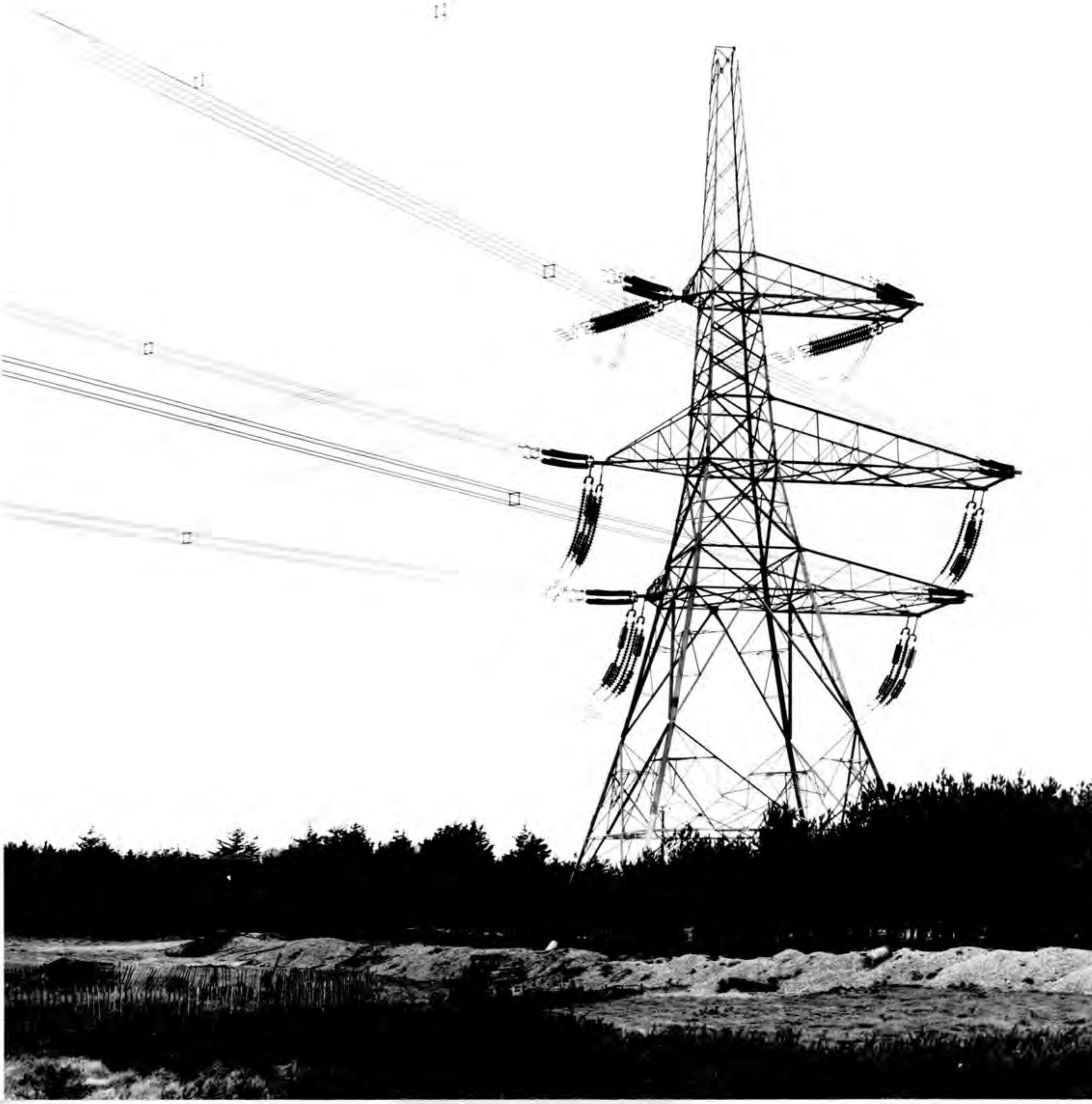
The Board seems to suggest that the larger towers would because of the wider spacing of the legs, permit agricultural operations to continue beneath the tower rather than sterilize the whole of the tower base area, as is the case with smaller towers. Photograph 11 published by the Board (11) points to this argument, but it is thought unlikely that this opinion would be shared by many arable farmers.

Photograph 11. Combine harvester under a 400 kV transmission tower.

The rental payment is subject to Income Tax, (12) and the landowner may choose whether to adopt an annual rental payment, or a once and for all payment, which would be a capital payment not subject to income tax or surtax. The compensation payment is simply to reimburse the farmer for the extra expense incurred because of the interference the tower causes to the most economical farming operations appropriate to the current use of the land. Since these payments are not based on loss of profits the Inland Revenue has agreed that such payments are not liable for tax. Both rental and compensation payments may be converted to a single lump sum, based on 20 to 25 times what would have been the annual sum. The owner/occupier is paid both the rental and compensation. If the land is let he can have the compensation if he is willing to assume responsibility for compensating his tenant for interference with agriculture and the tenant agrees to this. Alternatively if the land is let the owner may receive 10 times the annual compensation on the understanding that the tenant will continue to receive annual payments to the end of his tenancy, but any new tenant will receive nothing from the Board. Such an arrangement might be made where the compensation payable for the damage to the land because of the presence of the towers and conductors can with reasonable certainty be determined once and for all, for example, where a line crosses a rural land which had no prospect of future development. In return for a capital payment the Board will require the grant of an easement in fee simple. Permanent easements are generally an advantage to the Generating Board as they mean security for the retention of the line, and also avoid possible future claims.

Compensation is also payable for any damage done to land during the course of construction. It is inevitable that when a tower has to be erected on agricultural land involving at least 60 trips of heavy loads, some damage will be caused and in some cases under adverse weather conditions this damage can be very extensive. Ideally the contractor prefers to work at consecutive tower positions, and it is appreciated that the cost to the contractor of having to move to different tower positions back and fore along the line is probably greater than the cost of compensation to the farmer. Various figures have been quoted for the clear area required around tower positions, and the following may be quoted as rough guide.

For the construction of tower foundations an area about 50 feet outside the base of the tower is usual, and for the erection of the tower the contractor seems to spread himself over a roughly circular area the radius of which is equal to the height of the tower. Attempts are sometimes made by the Board to contain a contractor within a smaller area, but from observations of the author this seems to be rarely done. For



Photograph 12. An angle tower on the Lydd-Bolney 400 kV line, with stringing of the conductors in progress, showing a part of the land damage caused by the construction of these supergrid towers.

conductor stringing, the area required varies depending on what particular operation is to be carried out at the tower. Bearing in mind the fact that the crossarm width is approximately 60 ft. the width of area required will be approximately 100 ft. Assuming a standard height tower and that stringing will be carried out in both directions from the one tower length of area required in each direction along the line will be approximately 300 ft. The area required per tower position and likely to be damaged is approximately 2 to 3 acres for straight line towers and 3 to 4 acres for angle towers. 20 miles of line construction may therefore result in land damage of between 250 to 300 acres. There appears, however, to be little incentive to reduce this land damage as it seems to be cheaper for the Board to pay compensation, rather than delay the construction and commissioning of the line.

Aerial Spraying of Crops

The existence of wires and towers across land also creates a hazard to low flying aircraft, and thus prevents a farmer from obtaining the fullest benefit from the increasing practice of spraying his crops from the air. The Country Landowners Association and the National Farmers Union consulted the Board on this problem, and they agreed that the following clause should be included in the appropriate wayleave agreement:-

> "In the event of the grantor spraying any crops or pastures by aircraft and an area being left untreated owing to the aircraft's inability to spray close to the works, the grantor shall take all reasonable steps, including where practicable treating from the ground, to mitigate loss of crop on the area so left untreated by aerial spraying and the Board will bear the additional cost, if any, of such treating from the ground or if such treating from the ground shall not be reasonably practicable the Board will pay reasonable compensation for any loss of crop caused by inability to spray from the air close to the works. Provided always the provisions of this clause are conditional upon the grantor having given written notice to the Board of his intention to spray from the air in the vicinity of the works or if this shall not be practicable the earliest possible notice that such spraying has taken place."

It follows from this that where lines and towers prevent the aerial treatment of crops, then the farmer is to try and treat them from the ground, and claim from the Board any additional cost to him of giving that ground treatment. Such a claim could arise on a farm where a multiplicity of lines prevents the pilot from spraying all the crop from the air, but the terrain of the land enables the farmer to spray any part so untreated by the ground method. Where the presence of the wires and towers as well as the roughness of the ground, or condition of crops, prevent both aerial and ground spraying the farmer can claim for loss of crop.

It has been difficult to assess the number of successful claims for compensation due to the limitation on aerial spraying, as agreed claims are not published. Only those which are disputed and go to arbitration are recorded, and only one case had been found during the past few years. (13)

This case which was referred to the Lands Tribunal concerned a farm of 450 acres at Weston in Hertfordshire on which there were six towers. The advocate for the claimant said that the farm represented a capital outlay of about £120,000. The existence of the towers affected the desirability of the land and in this case it could lead to the price being reduced by £20,000. This statement was not however supported by his witness who said he valued the farm at £117,000 without towers, but £3,000 less with towers.

The loss of value to the farm because of the limitation on aerial spraying was made, but not particularly stressed. He agreed under cross examination that aerial spraying had not been used on his client's farm, but cereals were being grown at the moment and this was a crop that could benefit from aerial treatment.

The Board's surveyor said he assessed compensation at £1,400 calculated on the basis of the damage attributable to loss of land and the difficulty of cultivation beneath the towers, the obstruction of aerial operations, and the loss of amenity value. It is not on record what compensation he assessed under each of these heads.

The Tribunal in issuing its decision (14) included the following statement made by a tribunal member:-

> "I am satisfied that the use of aerial spraying is a practical possibility and that such use would be hindered and made more expensive by the presence of the power lines. The interference with the use of air equipment would be a bargaining point in this district, and I put the compensation under this head at £700".

The compensation was in respect of five towers erected in a 142 acre field which had been formed by the amalgamation of seven fields, so that modern techniques of cultivation could be used.

This decision leaves no doubt that the presence of towers and wires over land can seriously affect the aerial spraying of crops and is a legitimate claim for compensation in some cases.

Shooting

It is not often that a line affects the value of a shoot, but circumstances may arise when the position of a tower or conductors may impair the natural line of flight of game. Several instances are on record of a claim for compensation being made for this reason, but it has not been possible to find a case when such a claim was successful.

In one unsuccessful case (15) the freeholder took the view that the existence of the towers would reduce the annual value of the shoot from £70 per annum to £60 per annum, an annual depreciation of £10 which he capitalised at 25 years purchase to give a sum of £250. The occupier, who had shot over the land before and since the towers had been erected, gave evidence that there had been no material difference in the bag since the erection to towers and wires. He had never seen birds fly into the wires when shooting but had found dead birds under them. The Lands Tribunal decision was that they were not satisfied by the evidence that any damage had been suffered by the shooting rights, and accordingly made no award for compensation under that head.

5.5 Wayleaves through Woodlands

Electricity lines passing through or over woodlands interfere with the use of land for forestry throughout the whole of their length. Due to the need to maintain electrical clearance it is not permitted to grow trees to saleable timber size under lines, and to varying distances on either side, depending upon the voltage of the line. For example the safety requirements for a 400 kV line with the conductors spanning 1,200 feet between the towers, and allowing for their lateral swing in high winds will restrict the growing of trees over a total width of 240 feet. Thus for every 60 yards of 400 kV line one acre of woodland would be affected. This does not necessarily mean that the whole of this area would require to be clear felled although this is generally the case, but that trees must not be permitted to grow within a specified distance of the conductor. The owner has therefore to be compensated for his loss due to the restrictions on growing trees under the line. There is not a standard compensation payment agreed for all the various cases of lines over woodlands, since the damage sustained by each woodland owner will vary considerably according to circumstances and particularly on the quality of the land for tree growing. The main grounds for compensation concern the disposal of timber, clearance of the area and subsequent maintenance, valuation of the timber felled, the sterilisation of the woodland, and the effect of wind damage to the exposed faces of the woodland. It is proposed to examine each of these grounds for compensation in some detail as they directly result in some restriction of land use.

Disposal of trees

Where trees have to be felled the owner is free to decide whether to sell them to a timber merchant or to require the Board to fell and remove them, and pay compensation for their value. The decision will depend on such factors as the total volume of timber, mixture of species, and the extent and manner of access to the woodland.

Clearance of site and maintenance.

If the owner prefers that the Board should not carry out the work of clearing the woodland and keeping the strip clear, the cost of this work would be an additional item for compensation. This will also arise if increased costs are incurred for any additional work necessary for the prevention of fire, the control of vermin, and the erection and maintenance of any additional fences.

Valuation of timber.

Where trees are to be felled compensation is payable for their value in so far as this had not been or cannot be recovered by means of a direct sale by the owner. This value is usually calculated by one of the following methods according to circumstances:-

(a) If the trees are mature, or nearing maturity, their market value as timber.

(b) If the trees are not mature but their value exceeds their establishment cost they are valued on their "expectation value". This is their estimated value at maturity discounted at an appropriate rate per cent, according to species and site quality, back to the date of felling.

(c) In the case of young plantations their establishment value. This is the cost of establishing the trees and bringing them to their present stage of development. This will be made up of planting and other establishment costs plus compound interest at a rate appropriate to the species and site quality.

Sterilisation

If woodland crossed by a line cannot be used for forestry its value may be reduced from anything between £50 an acre to a few shillings an acre. The woodland owner is entitled to compensation for this loss in value and compensation usually takes the form of a sterilisation rent. A claim based on loss of profits recognises that a tree crop may earn between 2% and 8% on the capital employed, depending on land fertility, situation and the species of tree planted. Power lines which cross a wood near to its edge can sterilise not only the strip immediately below, but also areas on the border of the wood which may become uneconomic to plant. Sterilisation rent is also payable for such areas and further claims for vermin control, fencing, injurious affection to adjoining land by enroachment of scrub, may be justified. The sterilisation rent of £1 per acre per annum agreed between the Board and the Forestry Commission some years ago, and understood to be under review, is not appropriate to every case. This was agreed only between the Board and the Forestry Commission and related to the poorer quality land normally owned or occupied by the Commission. Examples of compensation rentals known to have been negotiated by Woodland owners vary between a figure of £1 and £5 18s. per acre.

Windblow and marginal damage

Where a swathe is cut through a wood to make way for an overhead line, windblow damage may result. The cutting of a swathe will also result in new margins to a plantation. Trees on the margins do not grow as well as trees in the middle of the wood and suffer from exposure. Compensation can be claimed for such loss, and cases are known where a wastage figure of 10% to a depth of quarter of a chain on both sides of the strip has been accepted.

5.6 Electrical Clearance to trees

The Board is often criticised for its apparent lack of care in lopping and felling trees in order to string the overhead line conductors. (16) Any observant traveller will have seen instances of a swathe cut through a woodland which exposes the heart of a wood and leaves towers and conductors very conspicuous from a main highway. The mutilation of the limbs of a tree are frequently seen in the proximity of a line, and one may wonder why this is done.

Please turn over for:-
Map 19 indicating the location and extent of the air photograph opposite the map; showing the extent of tree felling through woodland required for the electrical clearance of a 400 kV line, at The Rough Park, Amersham.

EAST CLAYDON - IVER 400 kV LINE
COWLEY - IVER 132 kV LINE
LIMIT OF VIEW OF PHOTOGRAPH
The Rough Park
Tragoe's Plantation
Tragoe's Wood
Priestlands Wood
Woodrow High House
Woodrow
Childs Farm
Woodrow Farm
Model Farm
High Lands
Mop End
Mop End Farm
Penn Street
Pennstreet Farm
Holy Trinity Church
Vicarage
School
Lych Gate
War Memorial
Allotments
Factory
Lodge
Beamond End
Beamondend Farm
Little Summerville's Wood
Turkey Wood
Little Turkey Wood
Breaches Wood
Mopend Lane
Tobbys Lane
U P P E R

Photograph 13. A section of the East Claydon-Iver 400 kV line through the Forestry Commission plantation at The Rough Park, Mop End, near Amersham, Buckinghamshire. This air photograph illustrates the extent of tree felling required in order to provide for construction and electrical clearances.

Before construction starts, the contractor appointed by the Board to build an overhead line is required to carry out a detailed land survey and establish the accurate centre line of the towers. It is also the contractor's obligation to mark all trees to be cut, produce a schedule locating all such trees and their approximate girth. He will identify the trees where possible, but this is not a condition of his contract with the Board. It is understood that the Board has also recently agreed with the overhead line contractors that where woods are concerned the contractor shall mark the external line of trees to be cut.

Following this survey the surveyor will indicate the majority of trees that will have to be removed either for the footing of the towers or stringing of the conductors. Sometimes certain trees are excluded from felling in anticipation that the necessary electrical clearances can be obtained when the conductors are erected. There are however far too many occasions when the contractor because of thoughtlessness or lack of proper supervision has felled trees indiscriminately the full width of a swathe along the whole route of the line. In order to ensure that this does not happen and that no unnecessary tree felling occurs it is evident that the Board should be requested by Planning Authorities and landowners to insist that these contract conditions are rigorously enforced on every occasion, and supervised by the Board.

For electrical reasons (17) it is necessary to ensure that all overhead lines maintain a certain specified distance (18) from the ground trees and other objects. This is set out in Table 2.

Objects	LINE VOLTAGE IN KILOVOLTS					
	0-33	33-66	66-110	110-165 (132)	165 (275)	(400)
	MINIMUM CLEARANCES IN FEET					
Ground	17	20	21	22	23	25
Roads	20	20	21	22	23	25
Artifacts	12	12	12	12	15	18
Trees	12	12	12	12	15	15
Orchards & Hop Gardens	20	20	20	20	25	25

Table 2. Electrical clearance required to 132, 275 and 400 kV lines.

It will be seen that a 400 kV overhead line must be kept at least 15 feet away from any tree or hedge growing under the line, and that a minimum distance of 25 feet clearance is also required from the ground. These distances are slightly less for lower voltages.

The limits of the height to which trees and shrubs may be permitted to remain or grow under high voltage lines are shown in diagram 5. This diagram is based on standard height towers, level ground, with the conductors at their maximum sag, which is in still air conditions at a temperature of 122°F. The righthand side of the diagram shows the theoretical limit of tree growth height to fulfill the specified conditions at mid-span, and the lefthand side of the diagram shows the clearance required at the tower. Apparently a certain amount of discretion is possible when considering the felling or lopping of an individual tree. The Board has said for example, that is might be possible to accept the risk of a sound oak tree which could fall within the danger limit, where it would not be acceptable to save an elm tree which is more liable to fall in a high wind.

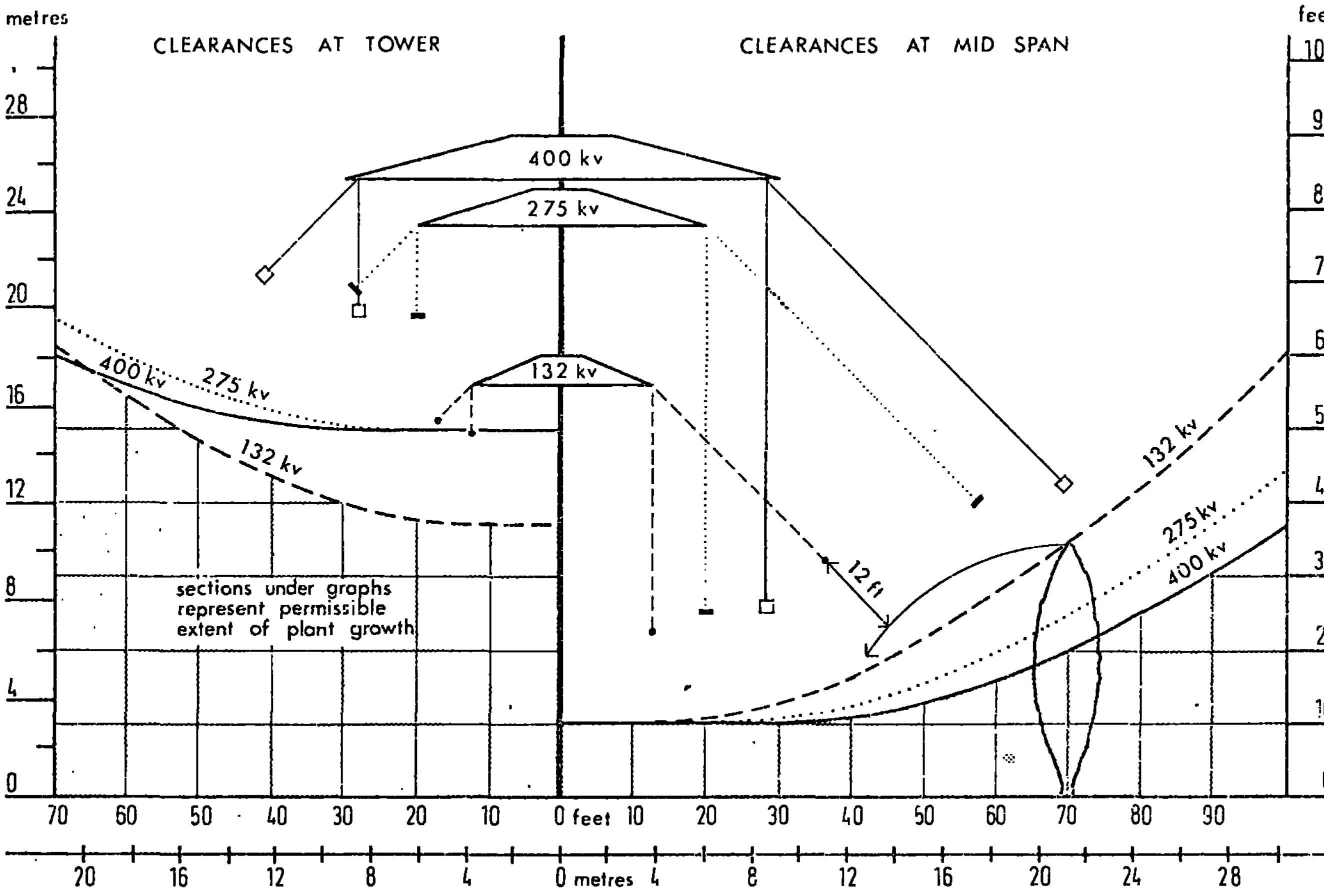


Diagram 5. Tree clearance limits for 132, 275 and 400 kV lines. (19)

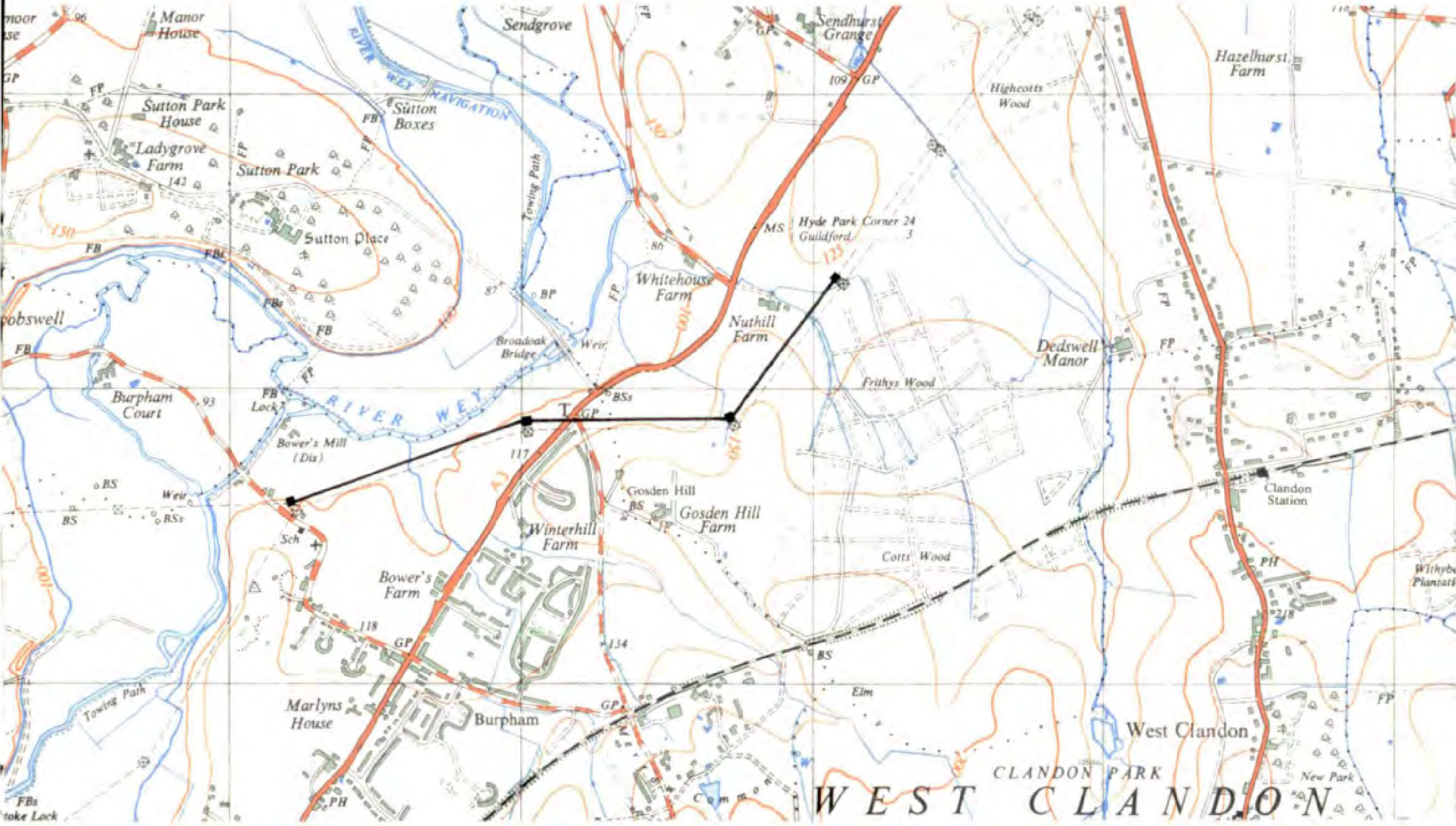
The general practice of the Board is to fell all trees within a 70 feet strip along the route of the line, so that the conductor may be laid out along the ground and winched into position. After the line has been erected there is no reason why trees and shrubs should not be allowed to grow up to the clearance limit. Photographs 14 and 15 illustrate two instances where minimum tree lopping, been carried out at the insistence of the landowner, has resulted in badly mishaped trees. It is usually better, if the minimum cutting has been done to obtain the required electrical clearance, for further tree lopping to be carried out to restore the natural outline of the tree. If this is well done it is not easy for the casual observer to notice that the tree has been reshaped.

Such tree surgery requires more time and effort by the Board, an insistent landowner who knows that it can be done, and perhaps most important of all a woodman with the eye and sensitivity to carry out the work skilfully. It is not easy to find good examples of tree re-shaping but the beech tree to the left of photograph 15 shows that it can be achieved. There are far too many instances when the Board has cut a larger swathe than was absolutely necessary, and has shown a lack of regard for good woodmanship. Photographs 20 and 21 are two typical examples.

It is possible to reduce tree cutting by increasing the height of the towers, but this is expensive, and may also be more visually offensive than the tree felling itself, by making the towers more obtrusive. The Board has said however, that they are prepared to incur this additional cost where they consider the circumstances are justified and where the higher towers are not objectionable, also if it is of genuine advantage. It is possible by special and more expensive stringing methods, to avoid clear felling.

The few occasions when the Board takes special care are frequently publicised and Photograph 22 shows the use of a fire engine ladder to avoid tree lopping, (20). Another instance which was widely publicised by the Board concerned a 275 kV line from Wrexham to Rednal, which was routed across a deep ravine at Bwlchgwyn. A rocket was used to carry a pilot wire which was used to haul the conductors across the valley, and by this means avoided tree felling. (21)

The Board occasionally uses helicopters to assist in the stringing of conductors across difficult terrain, and this technique has been used to avoid tree felling in a few exceptional cases. Photograph 24 (22) illustrates a typical case where the line erection presented a difficult problem of stringing over a combination of trees, rock faces, and steep slopes with a variation of height between 250 feet to 900 feet over a distance of three-quarters of a mile.



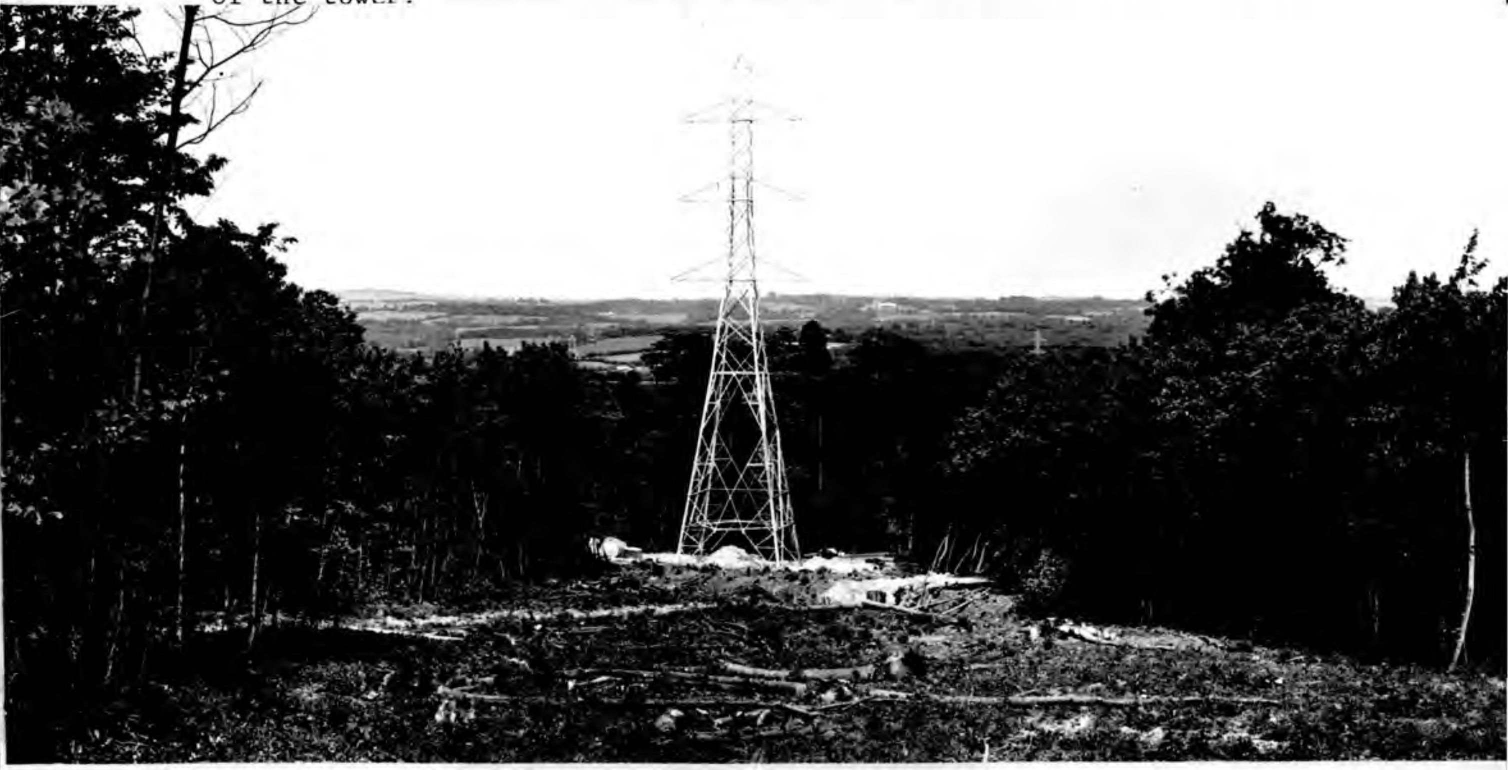
Map 20. Showing a section of the West Weybridge-Guildford 275 kV line where it crosses the A.3 about two miles north-east of the centre of Guildford, Surrey.

Photograph 14. These conifers bounded the north-west side of the A.3 adjoining Sutton Park. The owner Paul Getty insisted that only minimum lopping be done to comply with statutory regulations for electrical clearances. It will be noticed that the tops of the sawn trees form a curve very similar to that shown in diagram 5.

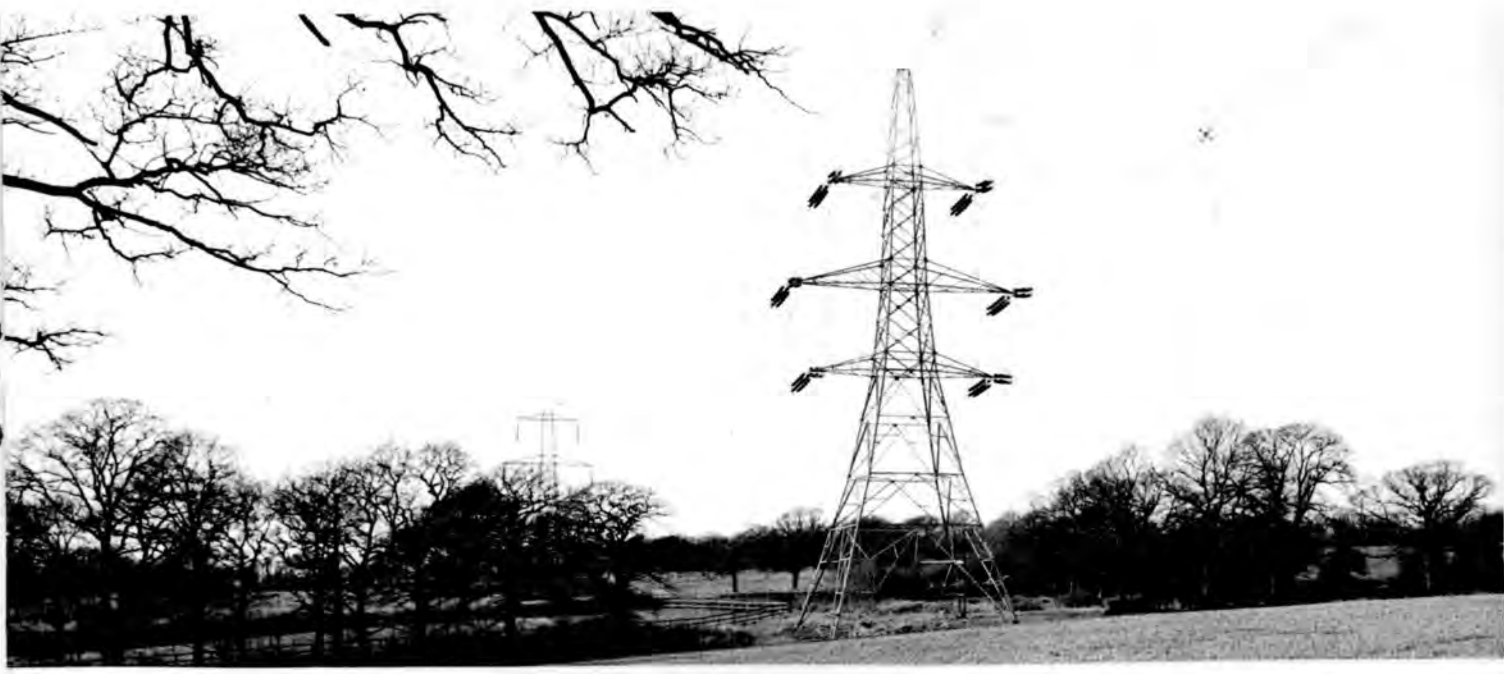
Photograph 15. A section of the Lydd-Bolney 400 kV line near Hurstmonceaux, Sussex. The two trees under the line were cut at the owners insistence to the minimum required to meet the electrical clearance regulations, and no reshaping of these trees was done. The tree in the foreground is a large Copper Beech, and this was lopped and side pruned by about 20 ft., and reshaped to conform to the natural shape of the tree.

Photograph 16. A section of the Lydd-Bolney 400 kV line near Hurstmonceaux, Sussex which illustrates minimum tree cutting.

Photograph 17. A section of the Ninfield-Hastings 275 kV line under construction adjoining Claremont School near Hastings, showing deliberate uneven felling along the sides of the swathe to give a more natural effect. The scaffolding near the tower is to carry the conductors during erection to avoid damaging or felling the trees near the base of the tower.



Photograph 18. A section of the Ninfield-Hastings 275 kV line showing minimum tree cutting.

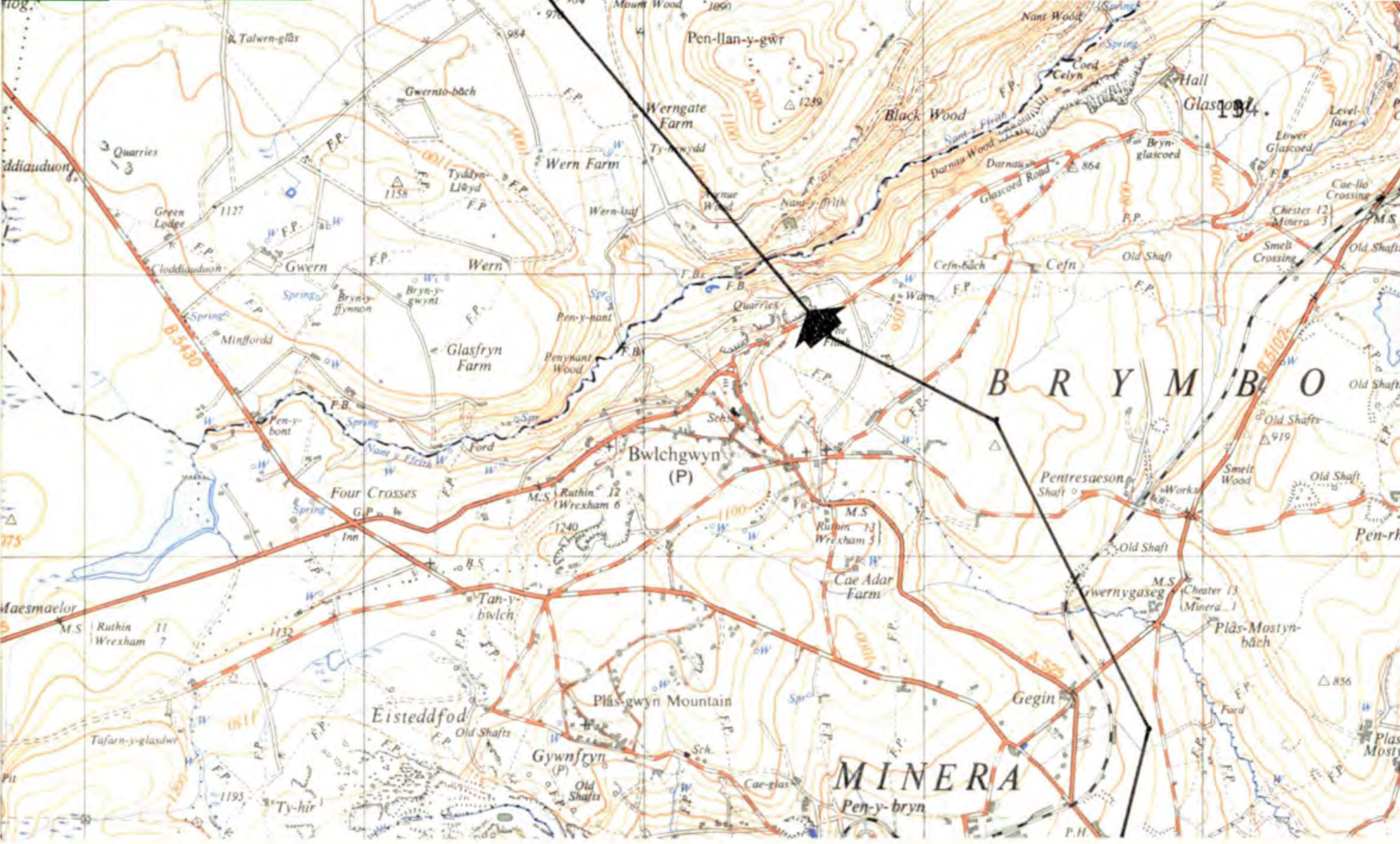


Photograph 19. A section of the Lovedean-Bolney 400 kV line, showing how this tower position required the felling of a line of mature hedgerow trees, which could possibly have been retained if the tower had been sited entirely on one side of the hedge.

Photograph 20. The last span of a 400 kV line into Cowley substation near Oxford. This clear felling has opened up a view into the substation, behind the photographer, from a road in the middle distance. This could possibly have been avoided if a few trees had been retained near the tower. The trees at the edge of the swathe, being formerly in the heart of the wood, and thus tall and slender, are very liable to be blown over in a high wind. See next photograph for view in opposite direction.

Photograph 21. Tree felling for terminal tower opening up view of Cowley substation, from opposite direction to photograph above.

Photograph 22. These trees formed a screen and provided shelter to an orchard in Kent, which required to be crossed by the 275 kV line between Canterbury and Lydd. A fire engine ladder is being used to provide access to the tops of the trees to lash timber poles to carry the conductors during erection to minimise damage, and to avoid felling these trees.



Map 21. Section of the Legacy-Connah's Quay 400 kV line where it crosses the steep valley of the Nant y Ffrith near Bwlchgwym, shown in the photograph below.

Photograph 23. A rocket carrying a pilot line was used to span the Nant y Ffrith valley, so that conductors could be pulled across without the need to fell the trees.

Photograph 24. Use of helicopter to carry a pilot line to link three towers on the Connah's Quay-Pentir line where they spanned the Aber Gorge in North Wales in order to prevent tree felling.

In all these operations of timber felling, and tree lopping the Board is under a statutory requirement to carry out this work in a 'woodman-like manner'. (23)

5.7 Depreciation in the Value of Property

The Board has said that there are over 10,000 gardens and houses under their lines throughout the country, built by both private developers, and by local authorities both before and after the line had been constructed. (24) The Board was not aware of any houses under their lines that remained unoccupied because of the presence of the high voltage conductors. However, this statement does not detract from the fact that such a line may diminish the value of a house where a line or lines cross land close to a house, and the presence of them can be shown to have depreciated the value of the house on the open market by their very presence. The assessment of probable depreciation to houses is one of the most difficult tasks a valuer has to undertake. Each case is taken on its merits though all assessments must be logical, one taken with another. The depreciation depends on the estimated value of the house and the effect of the line on that particular house.

At a recent public inquiry (25) an estate agent in evidence said that the erection of transmission towers would have a marked effect on the value of properties along the route. He gave an extreme example, a house valued at £15,000 which because of the adverse amenity effect of the line would only sell for half that price. The estate agent thought that a fair average of the approximate drop in value of larger houses would be £1,000. Admittedly a witness for the objectors at such an inquiry would be prone to exaggerate to some degree, but the evidence of an estate agent practising in the locality, with experience of other transmission lines in the area was not seriously challenged by the Board, and might be accepted as a fair statement of the facts.

An interesting case of a claim for compensation for depreciation in the value of property because of the proximity of an overhead line arose in 1960. (26) The Central Electricity Generating Board in 1941 had erected a 132 kV line from east to west across the estate of Cop Court Manor in the village of Tetsworth near Oxford. The Manor is a Queen Anne House of considerable charm and one of the towers, eighty feet high was sited directly behind the Manor and about two hundred and twelve feet from it. Between the Manor and the tower is a Moat, a pond with four elm trees of considerable size growing around it, and close to the tower a line of poplars had been planted as a screen since the erection of the tower, but owing to their proximity to the line they have had to be pollarded to a height of twenty feet from the ground in order to maintain the safe electrical clearance.

The value of the Manor in 1957 if there were no towers, was estimated by one witness for the claimant to be £8,000 and another witness £7,500. The former estimated that the pylons reduced the value by £1,500 and the other by £2,000. The surveyor for the Board gave the value of the property without towers at £6,000 and the depreciation in value due to their existence at £350. The Tribunal in its report said:- (27)

> "I have viewed the property and in the light of what view I am satisfied that the existence of the pylon and wires does not materially detract from the enjoyment of the very attractive property. At the same time I am satisfied by the evidence that it would prove a deterrent to some, and form a strong bargaining point in the case of all prospective purchasers. I have arrived at the conclusion that the sum which should be allowed is £750."

Only one other instance has been found during the past twelve years of a case that had been referred to the Lands Tribunal. (28)

The Board does not publish the figure of compensation negotiated for depreciation in the value of property affected by the construction of the supergrid, and therefore one is not able to assess its total effect in terms of the cost of amenity loss over the whole country.

Map 23. Location of Cop Court, Oxfordshire.

Where there is a prospect of future development or increase in the value of the land being affected by towers and overhead lines, compensation is payable for this loss. This may arise because of a restriction being imposed on the size or shape of a building due to the siting of towers, and the safety clearances required for the lines. A loss may also result because of similar restrictions in the layout of building land, for example in the case of a housing estate when a tower occupies the position originally designed for a dwelling. Compensation is also payable for any abortive expenditure incurred by the provision of roads and services, because of any limitation in their use.

A clause in the standard wayleave agreements entitles an owner at any future time to claim compensation for any diminution of the value of property for its development by reason of the existence of towers and conductors across the land. The clause reads:-

> "If at any time during the continuance in force of this agreement the grantor considers that the value of his said property has for the purpose of its development or user been diminished by reason of the existence of the works thereon and gives notice to the Board, the Board will pay to the grantor as compensation therefore an amount equal to such diminution in value such amount in default on agreement between the grantor and the Board being determined upon the reference of either party to the Lands Tribunal under the Lands Tribunal Act, 1949, and the Land Compensation Act, 1961. Provided nevertheless that the payment of compensation as foresaid is subject to the grantor executing in favour of the Board an easement in fee simple free from encumbrances for the works across his said property".

No compensation can be claimed by the owner or occupier of a property for the detriment to amenity caused by the view of a line unless the line crosses, or there are towers on the land. There is no redress for the effect of a tower situated on somebody else's land.

5.8 Restrictions on Mineral Workings

Surprising as it may seem clause 13 of the form of wayleave agreement entitles the landowner to ignore the effect of a pylon and wire on his land and grants him the right to withdraw vertical and lateral support to any works on the land. In practice he will not do so for the consequences might be of an almost catastrophic nature.

At the same time the clause reserves to the Board a statutory right to apply to the Ministry of Power to have such restrictions imposed on mineral workings as are necessary to give sufficient support to the Board's works. If the Board felt obliged to obtain such authority to retain the pylons in their present position, then though the Ministry's decision may result in obliging the landowner to give sufficient support to them, it would follow that he would be entitled to claim compensation from the Board for the loss to him, or any mineral losses, incurred by reason of the sterilisation of the minerals which will have to be retained to give that support. If a tower stands on minerals which could profitably be worked open cast, the Board would be required to pay for the volume of minerals which cannot be worked in order to support the tower. If the maintenance of safe clearance to conductors would restrict the normal methods of working, so that it costs more to work the mineral, the Board would be required to pay the extra costs incurred. In the cace of undeground workings it is the usual practice of the Board not to purchase a pillar of support for a tower. It would seem that the reason for this is that is is probably less expensive to rebuild a tower that has suffered from subsidence to the extent of being dangerous, than to purchase a pillar of support for the many hundreds of towers that are sited over areas of undergound workings. It is also in the national interest that minerals should not be sterilised when they may be economically won, and that mining operations should not be made more difficult by having to work around pillars of support.

5.9 Conclusion

The general effect of a proposed transmission line is immediately to reduce the value of nearly all properties on the land directly concerned, as well as any dwellings from which the line may be seen.

The knowledge of a proposed line within the locality of land or property for sale would undoubtedly make the transaction more protracted even if the vendor succeeds in obtaining the full current market price (29).

The statutory requirements for the distance between conductors and objects, and the effect that this has on agriculture, trees, and woodlands, would seem at the present time to leave little scope for radical revision. Similarly the existing administrative machinery for the financial arrangements for wayleaves, compensation, and depreciation in value of property, is able to take account of changes in agricultural practice, and the value of money.

There is however one particularly important matter concerning the actual building of a line. There is no doubt that land over which an overhead transmission line is to be erected, will suffer considerable disturbance and inconvenience to farming use. If the work is done during the winter, and the commissioning programme does not permit any suspension of operations, the resulting effect on the land can be appalling. Heavy equipment and machinery under wet conditions can quickly turn a farm road into a morass, and building a tower under these conditions frequently creates a scene reminiscent of a devastated battle field. However careful the subsequent reinstatement of the ground, it may be many years before it can be restored to its former quality.

Most Board officials appear to be genuinely concerned that such disturbances to the land is caused by its contractors, but it seems that it is the economics of the situation rather than concern for the land and landowner that is the determining factor. It is said that every day that a new overhead line is delayed, the Board incurs increased costs in the order of tens of thousands of pounds because of the need to run less efficient generating stations, and it is denied the economic advantages of operating the incomplete part of the supergrid. When extra costs of this order are involved the claims made for disturbance and reinstatement of roads, hedges, and fields are insignificant. The Board tends to excuse this apparent lack of care for the countryside partly on the grounds that the whole scheme had been delayed for no fault of their own, because of objections and the time spent in public inquiries and by Ministers of Power in granting consent. The possibility of electricity power cuts, because the connection has not been completed, and the consequent public and parliamentary criticism of the failure of the Board to meet its statutory duty, has tended to make the Board's construction engineers concentrate on getting the line commissioned. This has been done with a seemingly total disregard of its effect on the land, which is so often regarded as simply a matter of compensation and reinstatement that can be dealt with after they have left the scene.

There are indications that the Boards proposals for future construction has been considerably reduced, and that this will provide a greater period of time for the preliminary negotiation and subsequent construction.

This should enable the work of overhead line construction to be carried out with a greater regard for the rural scene and cause less damage to the land.

CHAPTER FIVE

References

1. C.E.G.B. Statistical Yearbook 1968 table 16, p.24, 51,088 towers actual total.

2. Acreage of England and Wales 37,273,300 Ministry of Town and Country Planning, National Planning Series, 1944.

3. There are some few exceptions to this; gold and silver, petroleum and coal.

4. Electricity (Supply) Act 1926 Section 44(1) as amended.

5. Electricity (Supply) Act 1919 Section 22.

6. Electricity Act 1957, Section 32(3).

7. Electric Lighting Act 1882 Section 17.

8. West Midlands Joint Electricity Authority v. Pitt (1932), 2. K.B. 1. C.A.

9. First Report of the British Electricity Authority 13.8.47 to 31.3.49. Printed 16.12.49. page 41.

10. The Electricity Council Annual Reports 1964-65 Page 43, 1965-6 Page 53, also Country Life 10.6.65 Page 1456.

11. Power and the Countryside, published C.E.G.B. July 1966, Page 10.

12. It is understood that this is deducted by the Board when making payment, but only for rentals above 50 shillings.

13. Reported fairly fully in the Hitchin and Letchworth Pictorial 15th March, 1968.

14. Reported in the Watford Evening Echo 13.5.68 and referred to a 450 acre farm at Weston, Herts. The total compensation awarded for six towers on the farm was £2,000.

15. Lands Tribunal decision The Radnor Trust v. The C.E.G.B. 12. P. & C.R. 111. 17th October, 1960 also reported in The Estates Gazette Vol. 176 Page 1089.

16. This criticism was also made in the Merthyr Report which was called upon, "to examine ... hedgerow timber and to make recommendations as to the best means of securing ... the tending of hedgerow timber". H.M.S.O. 1955.

17. The technical data is derived from the evidence given by Mr. J. Prest a Senior Electrical Engineer of the C.E.G.B. at a Public Inquiry held at Chichester on 2nd April, 1963.

18. These distances are laid down in the Electricity Supply Regulations leaflet EL.C.53 1947 revised.

19. Diagram 5 has been compiled from three diagrams prepared by the Board being one for each voltage, which are freely made available to the public at every overhead line public inquiry.

20. C.E.G.B. publication "Power and the Countryside" published July 1966, p.18.

21. C.E.G.B. publication "Pattern of Power" page 21 first published July 1960, reprinted 1963 also appeared in the Wrexham Leader 12th November, 1965 and again illustrated in C.E.G.B. publication "Power and the Countryside" Op-cit. Reported in Electrical Review 8.4.60 p.717 and 13.5.60 p.925.

22. Electrical Distribution Jan. 1968 p.229, the house magazine of A.E.I. Cables.

23. Electricity (Supply) Act 1926 section 34 (4). A copy of this section is included as Appendix E.

24. Given in evidence by a Board witness at Keighley in July 1966 at a public inquiry into the Bradford to Darwen 400 kV line. A more precise figure of 10,397 was given by the Board's Wayleave Officer under cross examination at the public inquiry held at Newcastle upon Tyne on 12th-14th November 1968 into the Tynemouth to Gosporth 275/132 kV line.

25. This inquiry was held at Bexhill from 30.4.68 to 3.5.68 into a proposed 132 kV line from Ninfield to Crowborough in Sussex, a distance of 20 miles. The estate agent was Mr. Francis R. Penticost and he was reported widely in the local press, particularly the Kent and Sussex Courier 10.5.68 also Times 2.5.68.

26. The Radnor Trust v. The C.E.G.B. Op-Cit.

27. Lands Tribunal decision letter. Ref. 220/1959 p.4.

28. Lands Tribunal decision 12th April, 1957 in the case of Wrigglesworth v The Central Electricity Authority. The reference concerned the compensation payable for the right to cross a 3.6 acre plot with a 132 kV overhead line. The electric line upon which the claim was based was carried on two steel towers one of which to the east was placed 390 feet from the point at which the line crosses the boundary of the claimants land, and the other 280 feet from the west boundary. The line was 56.5 feet at the lowest point above the ground, and the distance the nearest conductor would ever come to the house would be 50 feet. The claim was for £2,347 which was the amount the claimant considered the property would suffer in loss of value in consequence of the line crossing the land. Tribunal decision that the compensation to be paid shall be £125. Estates Gazette May 1957 Vol. 169 page 573.

29. An exceptional case is known to the author when the vendor of a detached property which was situated immediately underneath a supergrid line, claimed that the presence of the line prevented him from obtaining what he considered the full market price if the line had not existed. The Board purchased the property at the asking price, and within six months had sold it for a greater sum. It is not known whether it is Board policy to purchase properties if a vendor experiences difficulty because of the presence of a line, but it is thought unlikely.

CHAPTER SIX

Undergrounding of Transmission Lines

6.1 Introduction

At practically every public inquiry associated with the establishment of routes for overhead lines, the proposal is advanced by one or other of the objectors that the lines should be placed underground. On the face of it, this appears reasonable. Most people have seen distribution cables of quite large dimensions being laid under streets or pavements, and it would seem logical that the same basic method should be applicable to the overhead line system. But when it comes to the extra-high voltage of the Supergrid, it will be shown that electrical and mechanical problems arise which make the cost of underground cables prohibitively high in comparison with that of overhead lines.

This investigation is into the effects on land use and amenity of installing high voltage cables underground. These effects may be better appreciated if a brief technical explanation is given of the main differences between an overhead line, and an underground cable.

6.2 Technical Description of a Cable

Air provides the insulation between the overhead line conductors, which are supported by glass or porcelain insulators on steel lattice towers. In underground cables the insulation must be provided by numerous wrappings of high-grade paper tapes. To improve the insulating properties of this paper, an oil or gas, which is usually nitrogen, is introduced to fill the voids in the wrappings. The insulation has then to be covered with a lead sheath to provide an impermeable layer. Further, as the oil or gas pressure might cause distortion of the lead sheath, bronze alloy tapes are applied tightly round it. These metal tapes must also be adequately protected against damage during handling and against corrosion when the cable is laid in the ground, and a protective covering, consisting of layers of waterproof cotton or hessian tapes overlaid with rubber or plastic material is usually employed. Finally a covering is provided of more waterproofed cotton or hessian tapes.

Having ensured protection of the conductor itself it is necessary to protect the complete cable against damage. The cables are laid in trenches, at least 3 feet 6 inches deep and 2 feet 6 inches wide and lined with timber at the sides to prevent the earth from falling in during the laying operations. To ensure that the cables are not damaged by sharp points of stones, flints, etc., they are laid on a bedding of about 3 inches of sifted soil or sand and covered over the top in a similar manner. As a precaution against mechanical damage, should subsequent excavations be carried out along the cable route, reinforced concrete slabs about 2 inches thick are laid over the length of the cable before the trench is filled in. Finally, the disturbed surface is restored.

An electrical conductor offers some resistance to the flow of current, and heat is generated as a result. The heat of an overhead line conductor is carried away much more quickly by air, than by the insulation and soil which surrounds an underground cable. The conductor in an underground cable must therefore be made larger than that in an overhead line, if it is to carry the same amount of power so as

Photograph 25. Construction of 400 kV cable.


P.V.C. Sheath
Tin Bronze tape reinforcement
Bitumenized cotton bedding tape
Lead alloy sheath
Copper woven fabric tape
Dielectric screening tapes
Oil impregnated paper insulation
Conductor screening tapes
Six segment copper conductor
Oil duct

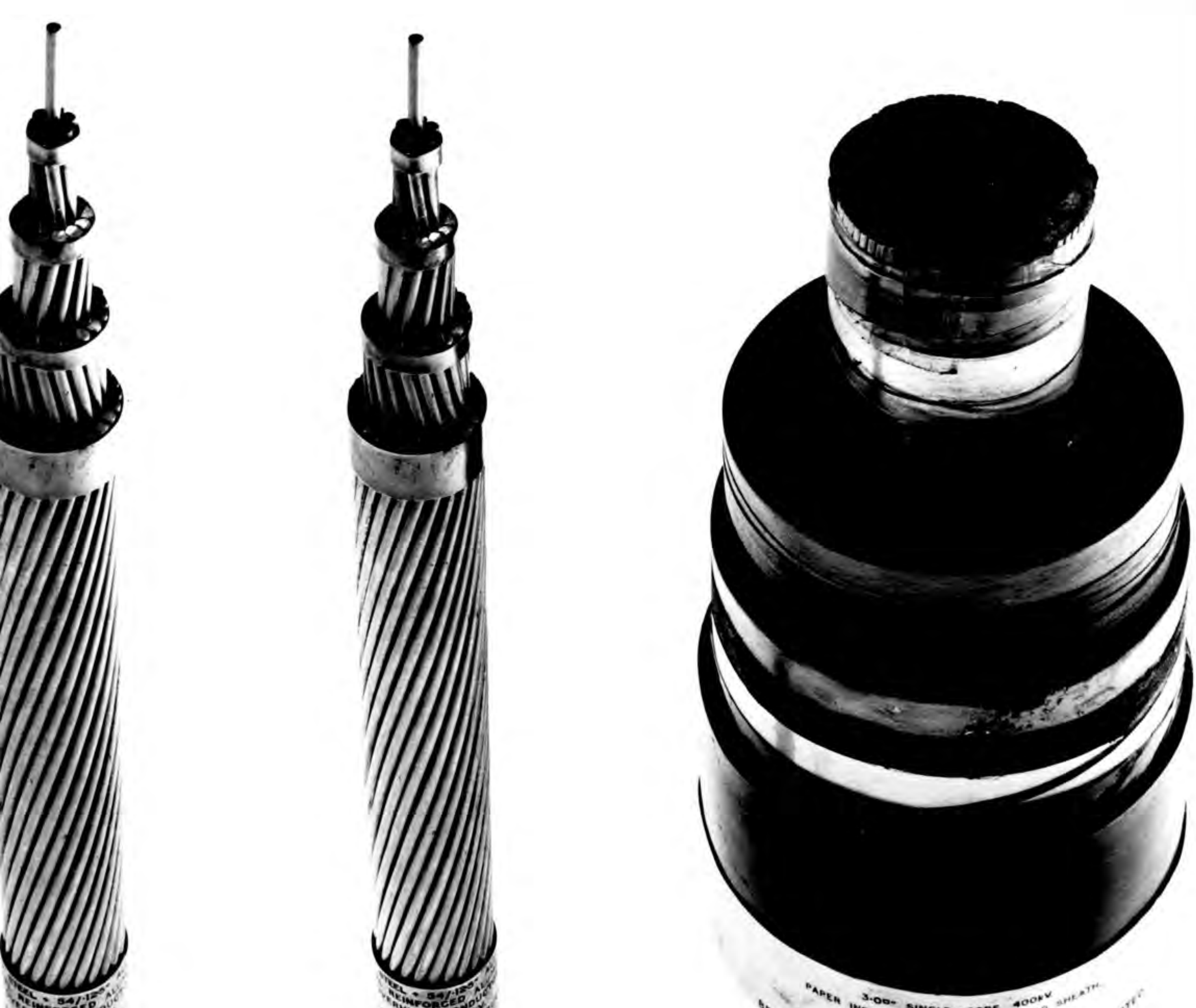
to afford less resistance to the flow of current and so produce less heat. The difference in size between a 400 kV overhead conductor and an underground cable of the same capacity is shown in the accompanying photograph. (1).

It is generally thought that cables being underground are more reliable than overhead lines, but the Board has said that failures on high voltage cables occur about as frequently as for equal lengths of overhead line. The time for the repair of a cable is, however, considerably longer and when this is taken into account the reliability of overhead lines is said to be about 70 times greater. (2).

6.3 Cooling of Cables

The first major 132 kV cable installation in the United Kingdom were the circuits between Deptford and Eltham. The route length was $6\frac{1}{4}$ miles and the cables were supplied and laid in 1930 by Pirelli-General Cable Works Ltd. By 1962 the C.E.G.B. were operating 402 circuit miles of 132 kV cable, and 2 milesof 275 kV cable. (3). These cable circuits had, from the early days of the Grid system, been operating on a cyclic loading basis, that is, they had not generally been required to carry their full rating during the summer, nor had they usually been fully loaded day and night.

During the summer of 1962, however, there occurred a cable fault that was to have far reaching consequences on the C.E.G.B.'s designs for future cable installations. A 132 kV cable that had been carrying its full load for a prolonged period, summer and winter, failed due to over-heating. The heat generated by the cable caused a drying out of the surrounding soil which reduced the ability of the ground to dissipate heat with a consequent further drying out of the soil; and so this cycle of events continued until the cable became so hot that it



Photograph 26. Two steel cored aluminium conductors of equal carrying capacity to one 400 kV cable.

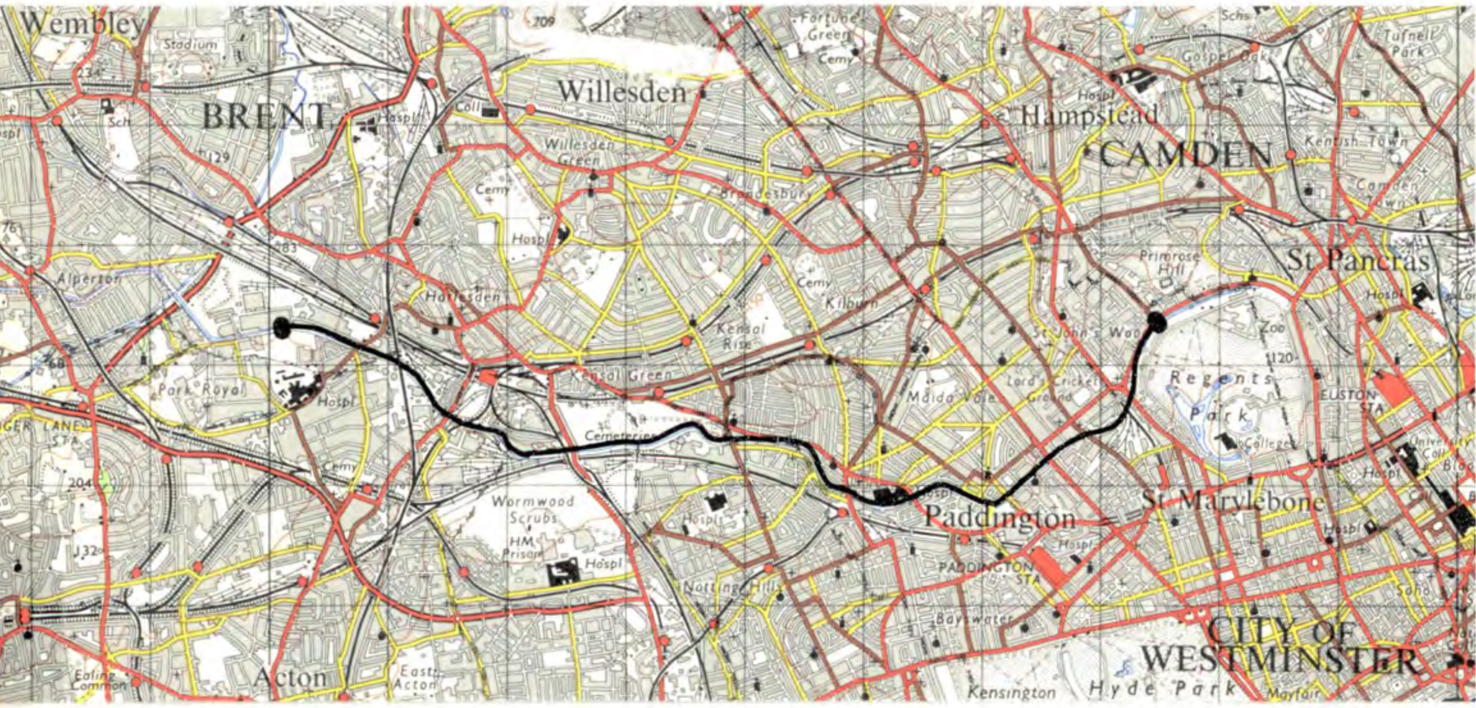
failed. It therefore became apparent that special measures would have to be taken by the Generating Board on future high voltage cable installations where there was a likelihood of continuous operation at full rating.

It seems that the Board to obtain the maximum operating efficiency decided that most of its future cable installation should have some form of assisted cooling for these high voltage cables. The Board has evolved three main cooling methods, which may vary according to circumstances.

Towards the end of 1962 the Board were planning to lay about 65 miles of 275 kV cable in and around London, (4) and some special provision had to be made to prevent the drying out of the ground. One solution to the problem of moisture evaporation from the soil had already been investigated in Canada by the Ontario Hydro-Electric Commission; this consisted of laying pipes alongside the cables and circulating water through them, to remove the surplus heat.

Whilst this work on piped cooling systems was going on, the Board was also investigating the possibility of laying high voltage cables in canals. It so happened that suitable routes could be found along the Regents Canal and the Grand Union Canal. Attention was first given to the possibility of laying cables in the canal itself, but after site trials it was established that the required heat dissipation could not be obtained by laying the cables in the water. It was found that silt would build up around the cables, become baked by the heat and would, in fact, constitute a remarkably good heat insulant.

The Board then investigated the possibility of laying cables in the towing path and a system using concrete troughs was developed. (5). These troughs were let into the ground so that when the concrete covers



Map 23 showing the 275 kV cable route from St. John's Wood substation to Willesden substation following the towpath of the Grand Union Canal.

Photograph 27. Towpath of the Grand Union Canal through Regents Park, London, showing concrete covers to the 275 kV cable troughs.

were fitted they would be flush with the surrounding area. One cable was laid in each trough which was filled with either a very weak mix concrete or sand. Tests had shown that either of these backfills readily conducted heat, and as the trough covers are not buried this heat was easily dissipated. This method would only be suitable in certain circumstances, as it involves a continuous line of concrete covers along the route. Photograph 27 shows the visual effect of this in the case of the 275 kV cable route through Regents Park. It would seem that this trough method of laying cables, would be possible alongside motorways or railways, or across open ground where considerations of visual amenity are not of major importance.

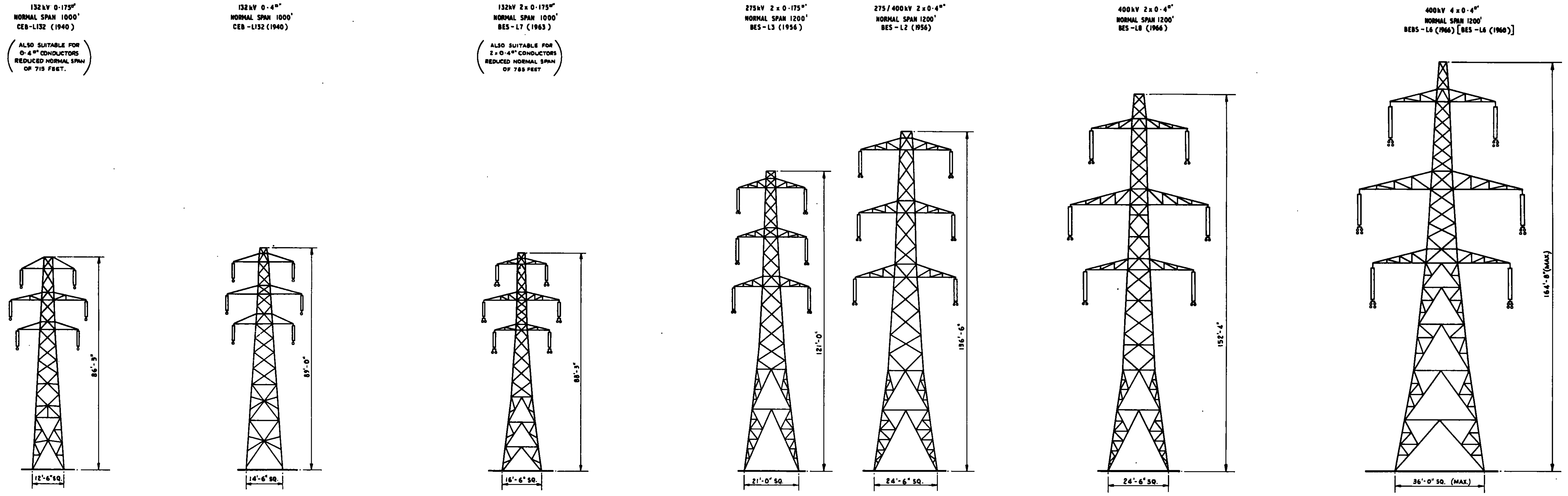
This method avoided the need for water cooling of the conductor which would result in some saving in cost. It had been estimated that this could result in savings of up to £250,000 a mile as compared with conventional underground lines. (6).

In the normal case the cables would be buried directly into the ground and drawing 1 shows the cable trenches and overall widths required to lay cables of the same carrying capacity as the overhead lines, and drawing 2 shows in greater detail a cross section through two circuits of a typical 400 kV cable route. (7). The cables are laid 6 ft. deep, in two trenches 8 ft. 6 ins. wide with the water cooling pipes running immediately alongside the cables. The smaller trenches either side of the main 400 kV cables are low voltage lines for monitoring and control of the cable route. The drawing also shows that room will be required for oil tanks to act as a reserve, and to keep up the oil pressure in the cables.

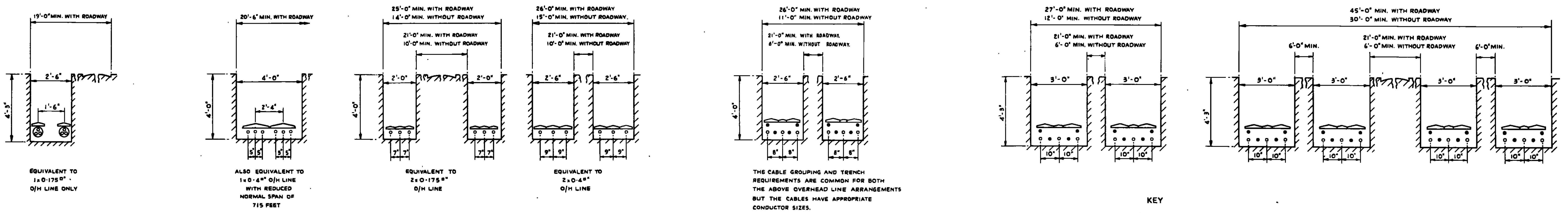
These dimensions vary considerably from those given in drawing 1 in respect of 400 kV cables which seems to indicate that the

OUTLINES OF SUSPENSION TOWERS
WITH APPROX. EQUIVALENT CABLE TRENCH REQUIREMENTS.

OUTLINE OF STANDARD HEIGHT DOUBLE CIRCUIT SUSPENSION TOWERS.



CABLE GROUPING REQUIREMENTS & APPROXIMATE TRENCH DIMENSIONS.



THE CABLE GROUPING AND TRENCH REQUIREMENTS ARE COMMON FOR BOTH THE ABOVE OVERHEAD LINE ARRANGEMENTS BUT THE CABLES HAVE APPROPRIATE CONDUCTOR SIZES.

NOTE: THE CABLE TRENCH REQUIREMENTS SHOWN ARE APPROXIMATE ONLY AND ARE SUBJECT TO MODIFICATION DEPENDING UPON THE WATER COOLING ARRANGEMENTS. IT WILL ALSO BE NECESSARY TO ALLOW FOR A 6'-0" WORKING SPACE ON EITHER SIDE OF THE ROUTE DURING TRENCH EXCAVATION & CABLE LAYING.

KEY

- CABLES (3 CORE)
- CABLES (SINGLE CORE)
- WATER PIPES
- CABLE COVERS

Drawing 1. Outline of Suspension Towers with approximate equivalent cable trenches.

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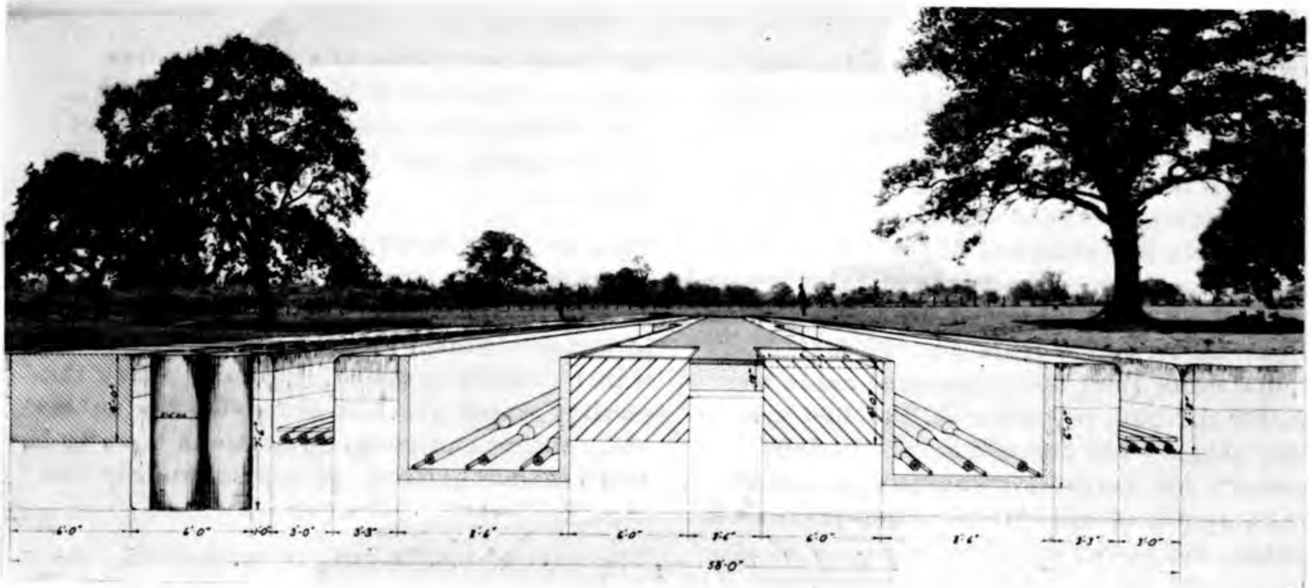
Board could only approximate as they have not yet installed cables of the full capacity illustrated. The diagram is however useful in presenting a general idea of the width of land involved for various cable voltages. Photograph 28 has been published by the Board to give some impression of a 400 kV cable route after installation with provision for a permanent 12 ft. wide access road, along the full length of the cable. Approximately every two miles a small building is required to house the cooling equipment and pumps for re-circulating the water.

The Board has recently published its proposals for the cable cooling of a 1.8 mile length of the Cowley - Bramley - Fleet 400 kV line which the Minister of Power decided should be placed underground as a result of a public inquiry. In this scheme the cable route is accross open ground, and for two circuits; two trenches each 4ft. 6in. wide, and 5ft. 8in. deep, at a spacing of 15ft. 0in. are required. Each trench will house one trefoil group of cables, and will be bedded in a backfill consisting of a mixture of a particular type of sand and gravel which the Board has found to have excellent heat dissipating properties. The top 2ft. 6in. of the trench would have a normal soil backfill, which the Board says will allow the ground to be returned to agricultural use, provided trees or hedges are not planted over the actual line of the cables.

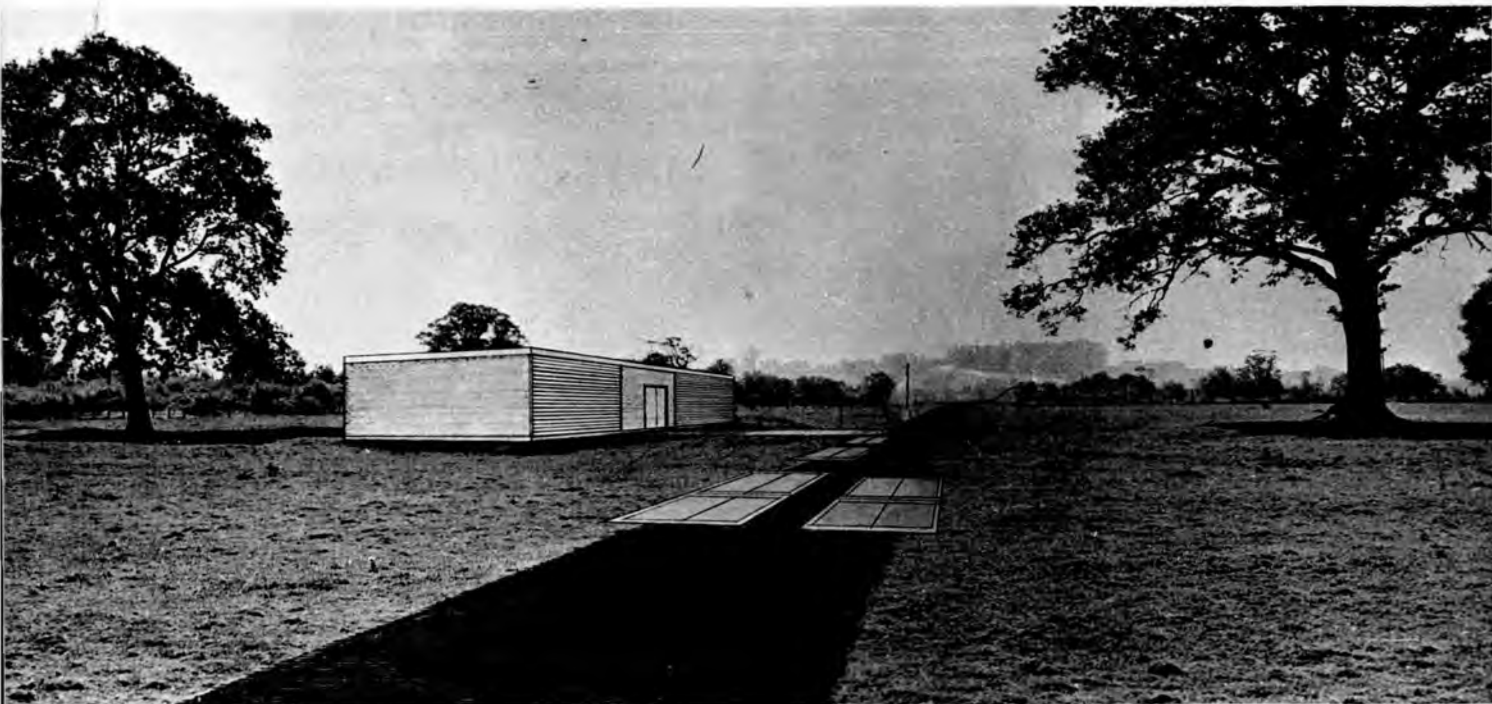
These then are the three methods adopted by the Board in dissipating the heat from the cables, and all three methods are frequently used depending upon the circumstances of local physical conditions.

6.4 Cable Costs

The earliest official published figures for high voltage cable costs appear in the C.E.G.B. Annual Report for 1962/63. Each year since



Drawing 2. A cross section of a typical 400 kV cable trench, with water cooling at stop joint and oil tank site.



Photograph 28. A montage published by the Board showing a cable cooling station, a surfaced road to provide access to the 400 kV cables, and the concrete covers to underground chambers containing water cooling equipment, oil tanks, and the joints between cable lengths.

Photograph 29. Shows the width required to join the three phases of one 400 kV cable circuit.

then the Board has published revised cable costs to take account of reductions due to more accurate estimating, and improved cable technology; which is offset by a general rise in production costs and the price of copper.

In 1963 (8) the approximate average cost per mile for two circuits of 400 kV cable was £1,226,000, and was 23 times more expensive than overhead. In May, 1967 (9) the cable costs had decreased to £1,050,000, and the cost overhead had increased by £11,000 a mile, but undergrounding was still 16 times more expensive. Over a period of four years this shows a modest reduction in the cost of cabling, but is not sufficient to affect the basic issue between these two methods of transmitting high voltage electricity.

The latest available cabling costs are as follows:- (10)

		Approximate average cost per mile for two circuits £000						
	Type	132kV 1x0.175	132kV 1x0.4	132kV 2x0.175	275kV 2x0.175	275kV 2x0.4	400kV 2x0.4	400kV 4x0.4
X	Double circuit overhead line	10.5	14	17	19	39	39	65
Y	Cable installation of equivalent capacity	90	130	155	240	315	465	915
	Extra for termination costs at both ends	10	10	15	40	40	65	120
	Ratio Y/X	10	10	10	15	9	14	16

Table 3 Comparison of costs of overhead lines and underground cables.

A breakdown of the costs for the largest 400 kV cable was published in December, 1964, (11) and a revision of these costs, so far as one has been able to find out, has not yet been published. A review of these costs is very much overdue in order to make them accord with the latest overall figure. However, the itemised costs are near enough to indicate the general order of expenditure.

	Per Mile	Per Mile
Cable		£484,000
Cable Installation		
Laying	£38,000	
Covers	£6,000	
Joints	£136,000	
Oil control equipment	£16,000	
		£196,000
Civil Engineering		
Excavation and reinstatement	£88,000	
Other civil works	£100,000	
		£188,000
Water cooling installation		£116,000
		£984,000
Sealing Ends		£72,000
	Total	£1,056,000

Table 4 Itemised costs of 400 kV cable.

The cost of installing 400 kV cable is so large that it is difficult to visualise it in any realistic manner. The Board has attempted to do this by suggesting that the cost of a 400 kV cable is approximately the same as required to build a mile of motorway. (12). The Board has estimated (13) that to place underground all future transmission lines would, even if practicable, require additional capital expenditure of between £100 million and £150 million a year, which is equivalent to an extra 6d. on the standard rate of income tax or to a 20 per cent increase in the cost of electricity. There would moreover need to be an immediate and large scale diversion of manpower and materials. On another and more recent occasion the Board said that if 100 miles of 400 kV line had to go underground it would mean diverting from the national capital resources men and material equivalent in cost to those needed to build 60,000 new houses or 300 miles of Motorway. Looked at from another angle, to put the grid system underground would add 4s. in the £ to our electricity bills. (14).

The Board has shown itself anxious to explain to the public the high cost of undergrounding 400 kV lines, and in May, 1965 published a booklet, (15) in the form of an open letter by John Sykes, an electrical engineer. Shortly afterwards an article (16) by the Right Hon. William F. Deedes M.C. the Member of Parliament for Ashford, and another article (17) by Edward Hyams, were reprinted; all these publications were in essence the plain man's guide to undergrounding and the cost of cables. It is thought that these Board publications have helped the public to obtain a better understanding of the basic issues involved.

6.5 Board's Expenditure on High Voltage Cables

The Board does not publish the amount it spends each year on high voltage cables, although it may be very approximately estimated by a simple calculation of the published figures of cables laid, given in Appendix C at the end of this volume, and the costs for each voltage given in Table 3 above. In 1962/63 for instance, 165 miles of 275 kV overhead line had been constructed at an estimated cost of £6,445,000 and 161 miles of 132 kV line for £2,254,000, for a total cost of £8,699,000. During the same period 5.86 miles of 275 kV cable would have cost £1,890,000 and 56 miles of 132 kV cable £7,280,000 for a total estimated expenditure of £9,170,000. The year 1962/63 was chosen for this example because the estimated figures may be compared with the official figures given in a Parliamentary statement which are set out in Table 5 below. (18).

	Overhead Lines	Cables	Proportion of total spent on underground cable
1962/3	£10,054,326	£9,093,683	47.5 per cent
1963/4	£15,508,920	£11,492,184	42.6 per cent

Table 5 Capital Expenditure on overhead lines and cables.

It will be noted that the estimated overhead line construction is considerably less than the actúal cost and the estimated cable costs are slightly larger. The reason for these discrepancies is not known, but may be partly due to the fact that a cable although carrying the stated voltage, is not necessarily of the same current rating as the equivalent overhead line. Although these figures relate to only two years they show an average of some 45 per cent of the total capital expenditure on transmission connections is spent on undergrounding. During the past five years covering the period 1964 to 1969 the Board spent over £80 m. on cables. (19). It would be relevant to endeavour to find out from official and authorative sources the likely expenditure to be incurred for undergrounding during the next few years.

As recently as 1959 the Board had no experience of undergrounding 275 kV cables. By March, 1965 (20) some 60 route miles of cable of this voltage were in service or being laid and experimental lengths of cable at 400 kV had been manufactured and tested. In the financial year 1964-65 about one third of the Board's total expenditure of £106 million on new overhead lines and underground cables was for cables, by 1970 it is expected that this proportion will increase to about two thirds of the total expenditure.

In the three years commencing in 1968 the Board expect to spend £107 million on 500 route miles of cable. Of the total sum to be spent on transmission reinforcement 22% would be on cables. In most cases the 400 kV cables will have only half the power carrying capacity of the overhead lines to which they are connected.

In May, 1965 (21) Mr. F. H. S. Brown, the Board's Chairman, in opening an extension to the Pirelli General cable works at Eastleigh, is reported to have said that in three years the Board intended to install 100 miles of 400 kV and 275 kV cable at a cost of about £52 million. The cables would have only half the carrying capacity of overhead lines which means that under 10 per cent of the capacity miles as cable would be responsible for 60 per cent of the total cost of the transmission reinforcement at these voltages. At 132 kV, 440 route miles of cable were planned for the same period at a cost of £55 million. Then 36 per cent of the capacity miles as cable would be responsible for 80 per cent of the cost. In October, 1965, the Board Published (22) the same statement, stating that this proposed expenditure on cabling referred to the Boards programme for the three years 1969 to 1971.

During the year 1966-67 the Board constructed 624 route miles of 400 kV overhead line, and reduced the total amount of 275 kV overhead line by 31 route miles, and at 132 kV by 174 miles. 26 circuit miles of 275 kV cable were laid and 173 circuit miles of 132 kV cable laid. (23). The total cost of cabling during that year could be anything between £23 and £36 million depending whether the lines were light or heavy duty. During this period the Board has said that it had willingly voted some £6 million for under-grounding purely for amenity purposes. (24). Of all undergrounding approximately 8% was necessary for engineering reasons.

The Board statements on its expenditure on cables is inclined to impress by the large sums involved, similarly if the costs of transformers or switchgear were quoted; but what is particularly relevant to this investigation is the amount spent on amenity cabling, and these figures do not seem to be available. It would help to form a clearer idea of the actual extent of amenity undergrounding if the Board published the actual amount of money spent for this purpose, as distinct from the total sum of cable expenditure.

6.6 Cable Research

Research on improved cables, and to reduce production costs has been a continual process ever since the need to transmit electricity became necessary. It has been difficult to assess how far the Generating Board has initiated such research, or the manufacturers, or whether both have been prompted by insistent public pressure. Both the Board and the manufacturers have a strong incentive to reduce the cost of high voltage cables; the Board because cheap cables would provide almost the complete answer to the transmission amenity problem, and the manufacturers because it would present them with the opportunity of becoming a world supplier of cables.

It has not been possible even after very considerable investigation to find out how much the Board and the manufacturers have spent each year on cable research. In the year 1955 - 56 the Board spent £16,000 on transmission research (25) and by 1959 - 60 this had increased to £2.5m, (26) but in neither case was there any indication how much of this expenditure had been spent in trying to reduce the costs of cable manufacture.

Stressing the need to evolve an underground cable which could be laid at a cost which is tolerable Sir Christopher Hinton the former Chairman of the Board said in June, 1961 (27) that the Board had studied the possibility of underwater direct current transmission links round the coast. Two cases were considered, one was in connection with the nuclear sites in Anglesey, which involved an underwater link to the Lancashire coast to avoid lines across North Wales; and the other sought to avoid additional lines through Sussex by a coastal cable running westward from Dungeness. In both cases the cost was prohibitive; at respectively, seven and a half, and fifteen times that of standard overhead transmission.

Early in 1963 the Board said that determined efforts were being made to reduce the cost of underground cables, (28) and at an exhibition (29) at the Royal Institute of British Architects sponsored by the Board, they reiterated that the Central Electricity Research Laboratories of the Board were exploring new techniques to produce conductors and insulating materials that would improve the current carrying capacity of cables. The Board then said that recent progress may make it possible to reduce the cost of undergrounding a 400 kV line to £750,000 a mile, but that there was little hope that underground transmission would ever be economically comparable with overhead.

In May of that year Sir Christopher Hinton in answer to a question before a Select Committee of the House of Commons, (30) said that a great deal of research on underground cables had, and was being done by the Generating Board, the cable manufacturers and the Electrical Development Association. It is not reported whether the amount expended was stated. The Chairman went on to say that the result of this research was that it was becoming cheaper to place lines underground. If the ratio of expense in March, 1962, of between 7 and 18 for underground lines to 1 for overhead lines could be reduced to 4 to 1, the Chairman of the Board said that he would advocate "extensive undergrounding". But he held out little hope for this reduction at high voltages, even though at voltages below 132 kilovolts it might be achieved within five or six years. In the event however the hopes of Sir Christopher Hinton were not realised and the costs of cabling today are appreciably greater than when he made these remarks.

In February, 1965 (31) a Parliamentary Secretary in answer to a question in the House of Lords said that the total expenditure on research and development was about £7 million, roughly £1 million was spent on transmission and distribution, and of this between 10 and 20 per cent was spent on cable research. He added that much other research was being done by manufacturers and that the Generating Board were placing contracts worth about £21 million for 275 kV and 400 kV cables 'of a pioneering type'. Later that year the Boards annual report (32) contained more impressive evidence than earlier reports of the research into the problem of undergrounding high voltage lines. A new cable system was being studied, consisting of a conductor supported by longitudinal spacers of solid insulating material, the major dielectric being a pressurised mixture of sulphur hexafluoride and nitrogen. The main problems were said to be in developing suitable terminations and in manufacturing the required section of solid dielectric in continuous lengths.

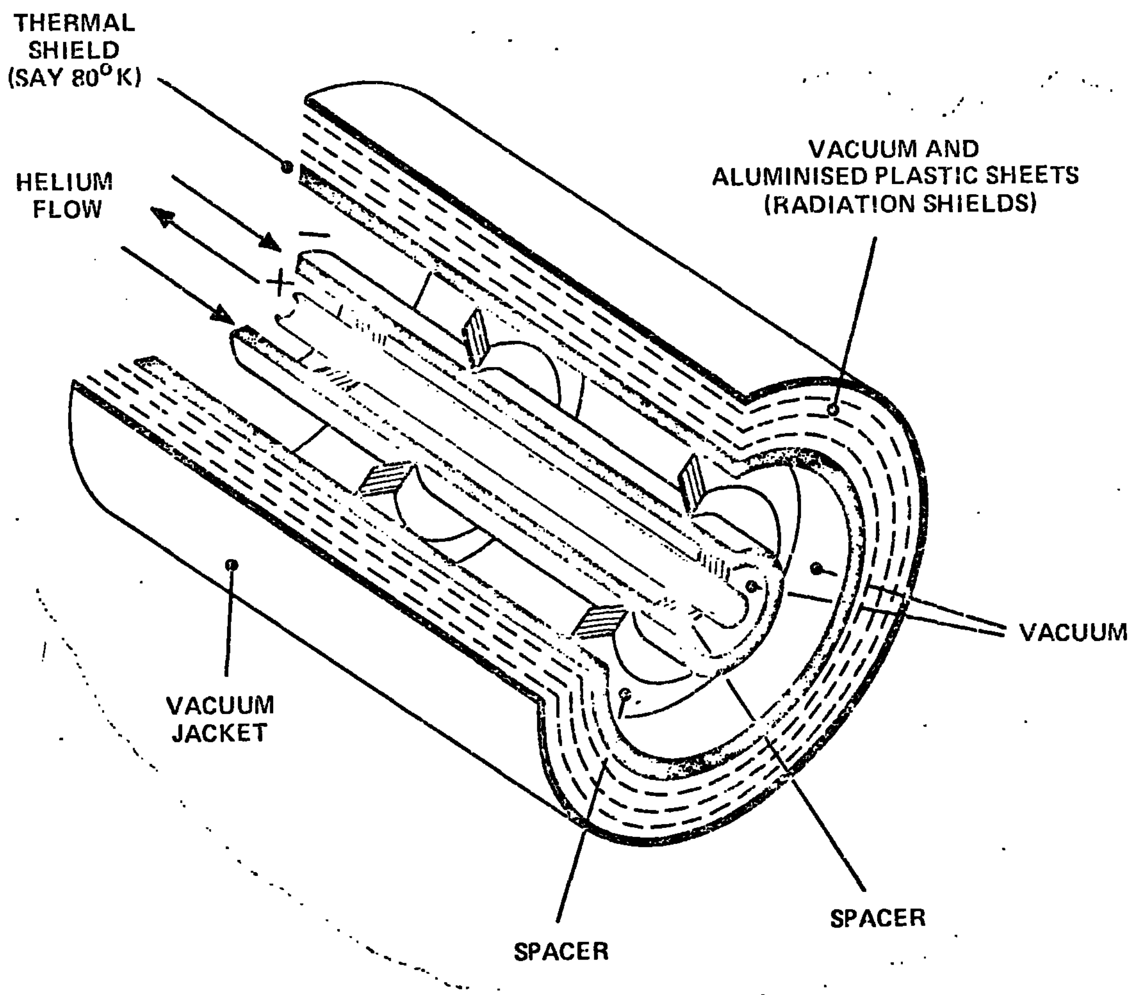
Several research programmes have also been initiated by manufacturers and universities to develop electricity cables in which the electrical losses would be much less than in existing materials, when it became clear a few years ago, (33) that it had become practicable to refrigerate large installations to such low temperatures that some metals would become super conducting. (34) In such a condition a metal would offer literally no resistance to the passage of an electric current. Drawing 3 is a preliminary design published by the Board to indicate the broad lines of current research. (35) It would seem however that neither of these techniques are likely to result in a major breakthrough in cable technology in the forseeable future, as the costs of such sophisticated installations would tend to cancel out any benefits likely to be obtained from the saving of electricity. (36)

In a comprehensive debate on electricity problems in the House of Commons in August 1965 (37) the Minister of Power said that research into reducing the cost of undergrounding was receiving top priority but there were formidable difficulties, and the most he could hope for was "some reduction in the enormous disparity" between the cost of underground and overhead transmission. The Board only last year (38) said that there was no immediate prospect either in this country or the United States (39) that research would significantly narrow the gap between the costs of overhead and underground transmission.

Quite frequently one comes across impressive figures of the total expenditure on research concerned with the electricity supply industry, but in every case no precise information is given of the amount spent on cable research. (40)

6.7 The Waddesdon Inquiry

In November 1964 at a public inquiry in the Village Hall at Waddesdon (41), the Board explained in considerable detail some of the visual and amenity problems that arise when undergrounding 400 kV. Counsel representing the Board explained that the dominant factor involved in cabling was the problem of waste heat. He said that the



Drawing 3. Possible construction for a d.c. cable with superconductor and thermal shield cooled by helium.

heat produced from underground cables of the type required, was equivalent to that from a one kilowatt heater every two yards. Heavy insulation was required with underground cables as opposed to the free air insulation of overhead lines, and the result was a cable weighing 877 tons per mile. He then went on to give details of the consequences of installing underground cable. There would be a 20-yard wide swathe across the countryside with a joint bay measuring 40 feet by 8 feet 6 inches every 240 yards length of cable. Stop joints for the oil impregnated system would be needed every six lengths and would require 50 square yards of land. Every two miles there would be a cooling station, 1,500 square feet in area and ten feet high, containg pipes and fans emitting a continuous hum. Photograph 28 is a copy of one displayed at the inquiry and illustrates the possible shape and size of a typical cooling station. A road to carry loads of 24 tons for laying the cables would also have to be built for access, for maintenance, and for possible repair of the cables and it might be necessary to have a permanent road 12 feet wide along the route.

The strip of country covered would have no trees, hedges, streams or ditches. Land drains would have to be altered, and there could be an increase in the soil temperature. There could be no building over this land. It would be a sterile strip preventing the normal use of the land, resulting in the introduction of industrial noise and life to the quiet countryside. It was suggested that the strips of "desert" and the installations might be more damaging to the appearance of a landscaping than a chain of 180 ft. pylons.

This ststement by Counsel backed up by the evidence of Mr. E.P.C. Watson, and Assistant Project Engineer of the Board's Transmission Project Group brought out aspects of undergrounding that had not been fully appreciated before. The Board seemed anxious to inform the public of these difficulties and issued a Press Statement with this information which received wide national press coverage in the technical press and local newspapers during the following months. (42) The Board also published two news letters setting out the problems of undergrounding in greater detail. (43)

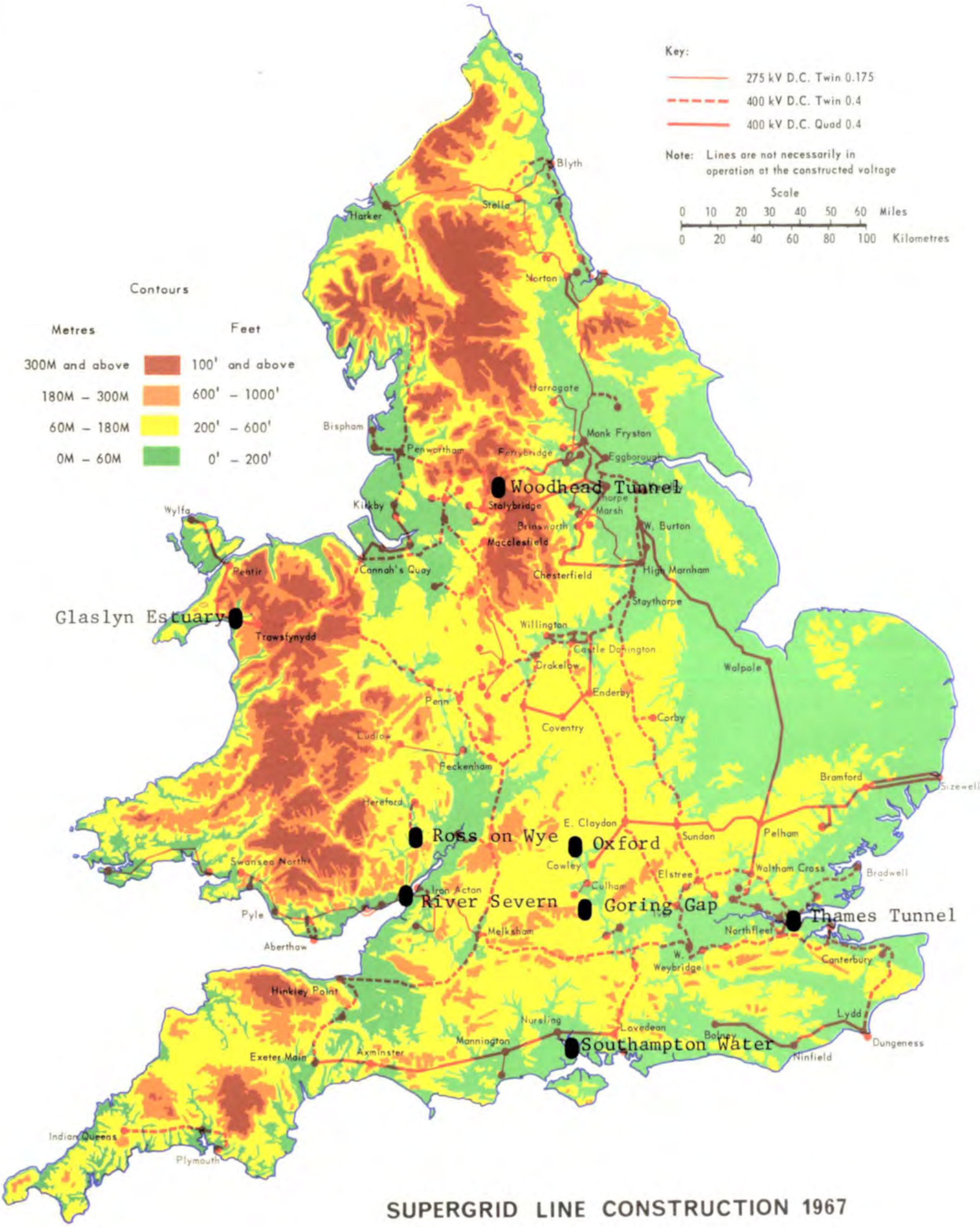
The Board's opinion that the heat from 400 kV cables would result in a sterile strip across country was challenged in debate in the House of Commons (44) and also by the Council for the Preservation of Rural England. (45) Since then the Board has not repeated the Waddesdon evidence and one may assume that subsequent experience and research may have enabled the Board to overcome these difficulties.

At a recent visit to the Glaslyn Estuary which is the only site where it is thought that any significant lengths of 400 kV cable has actually been installed and operating, (46) none of the amenity fears expressed at the Waddesdon inquiry are apparent.

6.8 400 kV Cabling Schemes

Much has been written and said of the one million pounds per mile of 400 kV cable. At the time of writing only a total of a fifth of a mile has been commissioned, which was 0.08 mile at Lydd and 0.12 at Eggborough and both of these were done for engineering reasons. Although this seems modest enough, there are also eight major schemes in various stages involving a total cost of about £15.6 million. Map 25 indicates the general location of these schemes, and it is interesting to observe that the one in the Peak District is the only one (47) situated in an area of a National Park or Area of Outstanding Beauty and yet all this undergrouding is being done solely to preserve visual amenity.

The Generating Board's Annual Report of 1964 (48) included the statement that of the cable installations authorised during the past year 6.6 circuit miles were at 400 kV. The total cost of this cabling is not given, or where it was to be installed.



Map 25. Location of 400 kV Cabling Routes.

Central Electricity Generating Board

400,000 Volt Overhead Transmission Lines

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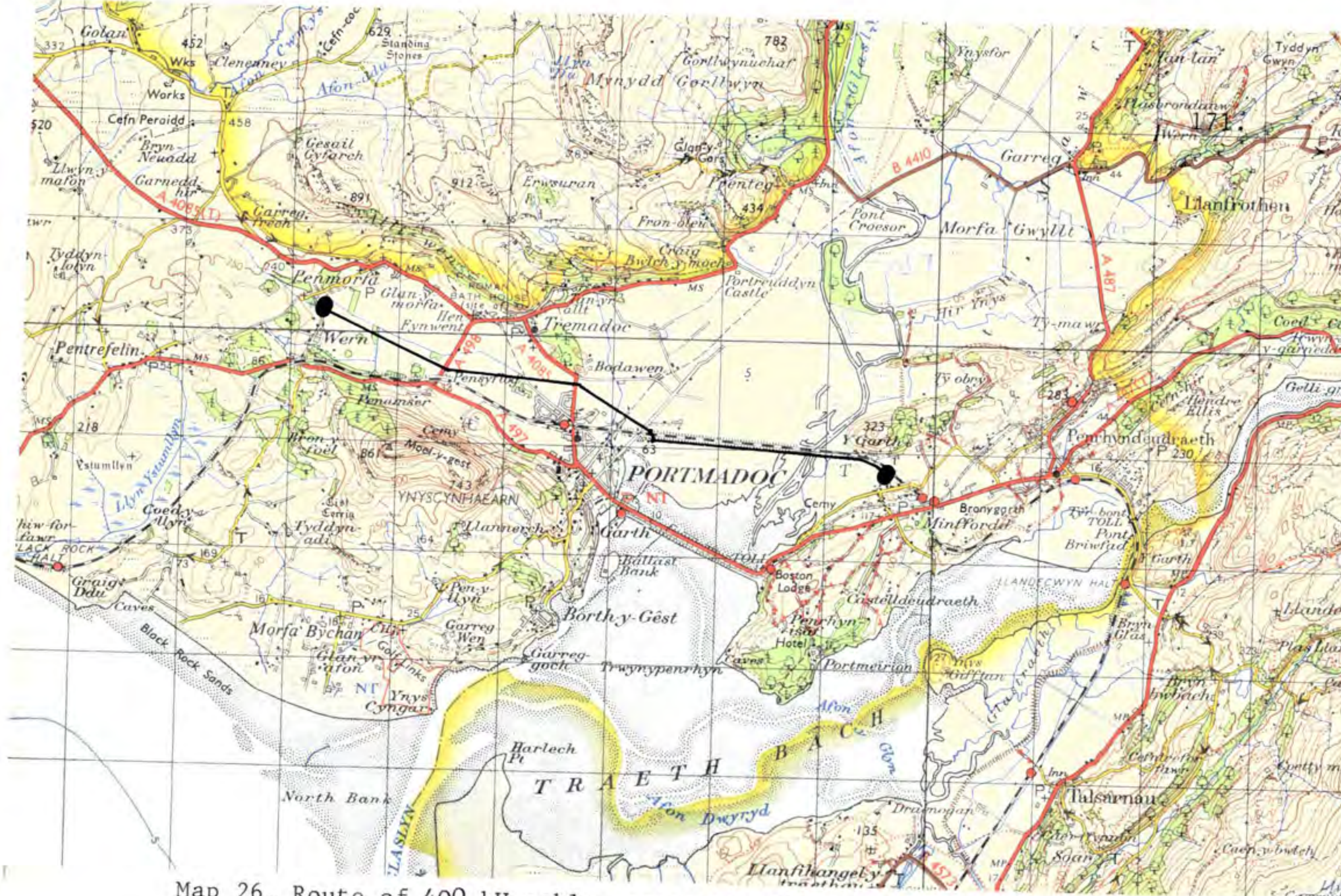
It may be worth while to briefly consider the circumstances of those cases that justified undergrounding at a million pounds a mile.

Glaslyn Estuary

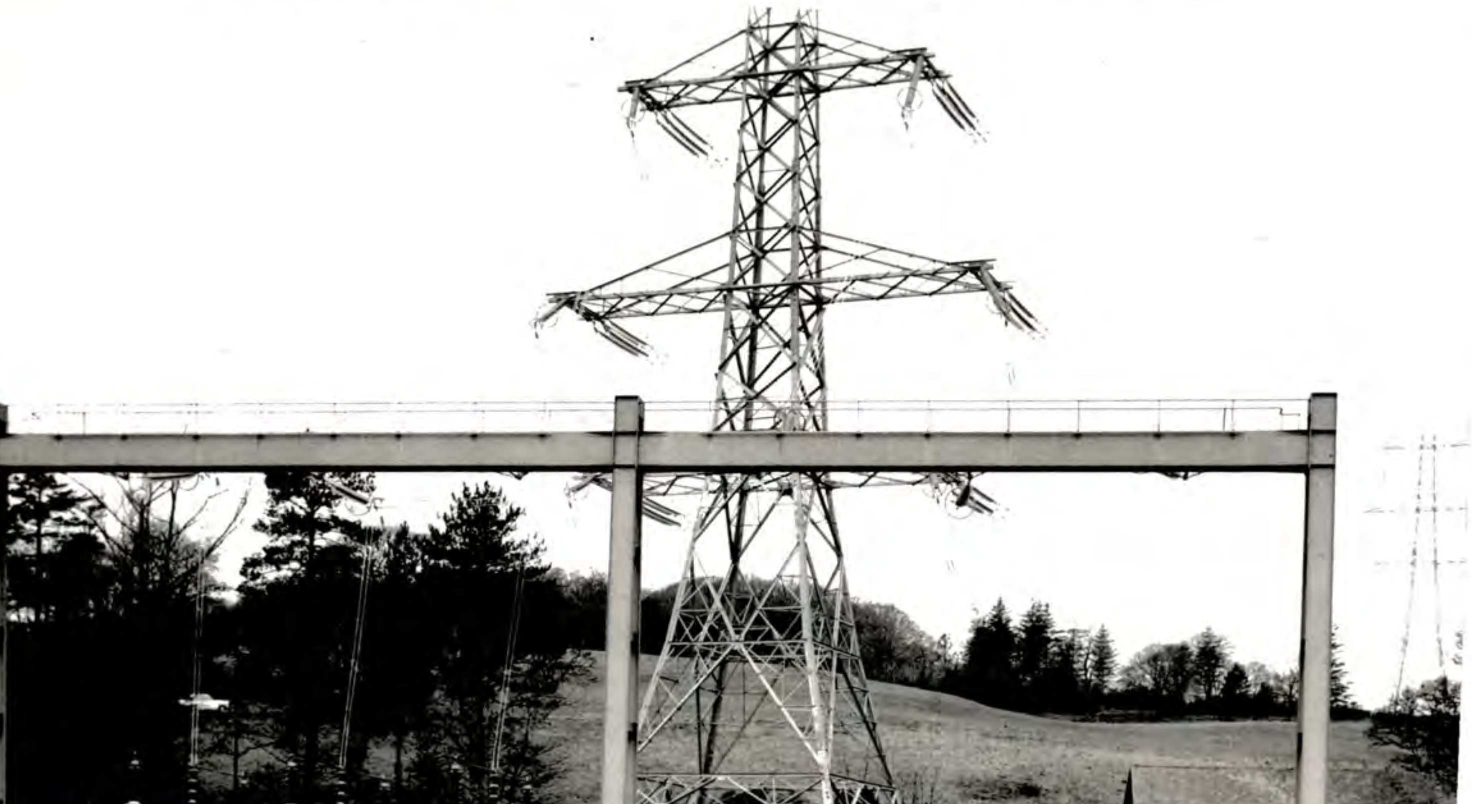
Map 26 shows the route of this cable which runs from Wern M.R. 544402 in Caernarvonshire to Y-Garth M.R. 597839 in Merionethshire a sitance of about 3½ miles. This was the first major 400 kV cabling scheme which was to preserve the view of Snowdon from the Glaslyn Estuary. The Trawsfynydd to Bangor line would cross this view and the Board recognising the strength of the objection to such a proposal hoped to meet it by offering, prior to a public inquiry in May, 1962, to underground 2 miles across the most vulnerable part of the Estuary. The Minister of Power not only accepted the Boards proposal, but also supported the suggestion put forward by the National Parks Commission (49) and many other objectors that a further 1½ miles of undergrounding westwards was necessary to give greater protection to the area. The Board therefore became obliged to underground this further length, the total cost of which is estimated to exceed £4 million. (50) The work has now been completed.

Woodhead Tunnel

Early in the 1960's it became apparent that as part of the 400 kV supergrid, a high voltage link was required between Thorpe Marsh generating station in Yorkshire and Stalybridge in Lancashire. The C.E.G.B. sought permission to route a 400 kV overhead line over the Pennines, to which strong opposition was raised by the Peak Park Plannning Board. (51) This resulted in a public inquiry being held into the proposal, (52) during which it was suggested that the disused Woodhead railway tunnel (53) should be used for a cable route, as a cheaper alternative than undergrounding in the conventional manner.



Map 26. Route of 400 kV cable across the Glaslyn Estuary between Y-Garth and Wern.



Photograph 30. Terminal tower and sealing end compound at Wern where 400 kV cable is connected to overhead line.

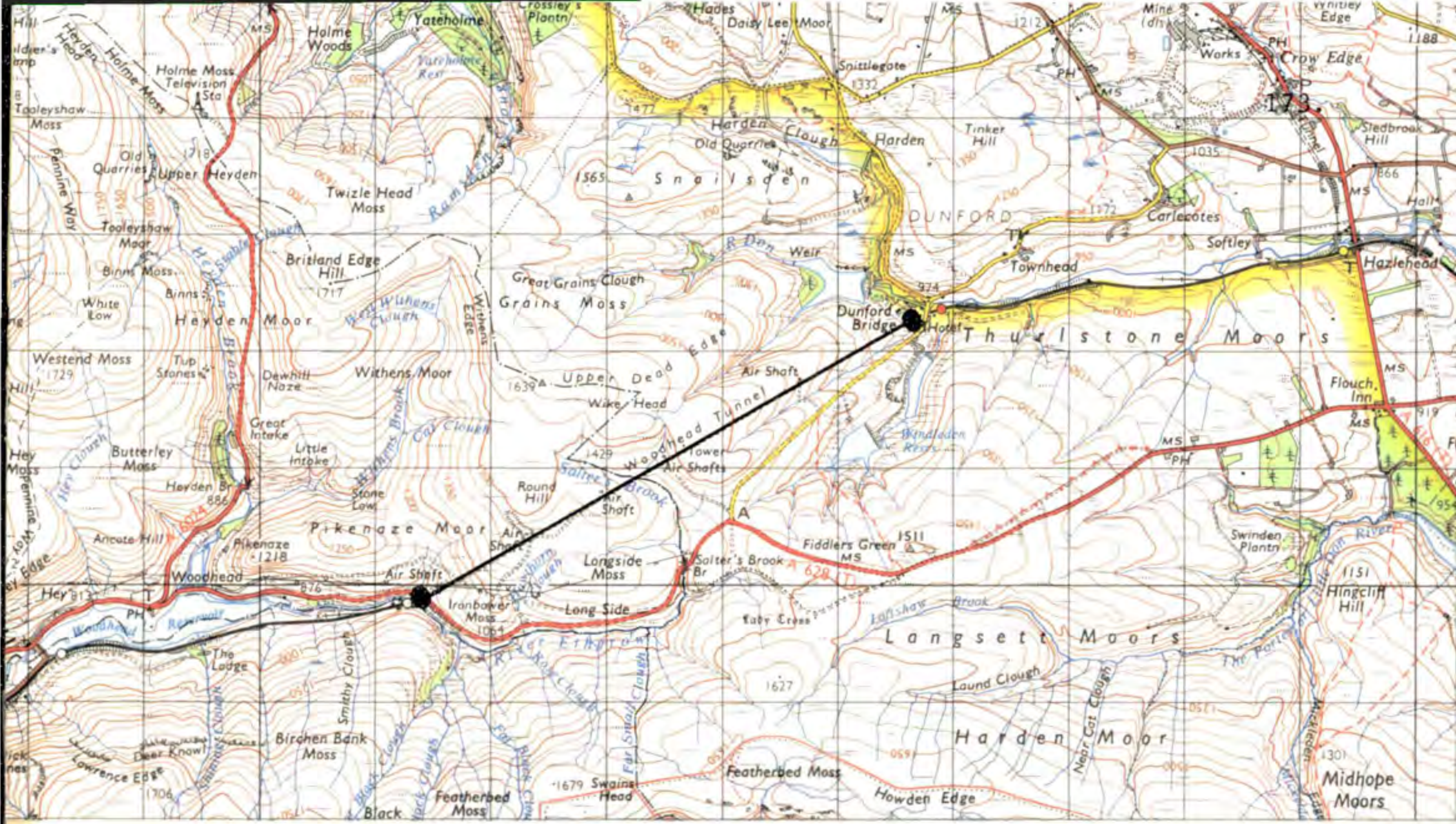
The Minister of Power accepted this argument but in view of the urgent need for the power link, consented to the construction of a temporary 275 kV overhead line between Dunford Bridge and Woodhead, but required the permanent 400 kV connection to be made by cable via the disused Woodhead tunnel.

Had the C.E.G.B.'s original plan for an overhead power line been accepted by the Minister of Power, the total cost of the link would have been in the region of £250,000 and it would by now have been completed. Going over the top of the Woodhead Pass, burying the cable in the conventional manner might well have cost about £5,000,000, bearing in mind the difficulties of the terrain. Utilising the old railway tunnel is expected to cost about £1 million in civil works and a further £1½ million for 3.6 route miles of cable. (54) To this must be added the cost of erecting the temporary link, and the total cost of the tunnel project will be about £2¾ million. The cable installed would be equal to only half the capacity of the overhead line and, although this is sufficient for the immediate future, the capacity and cost will have to be doubled later as loads grow. (55)

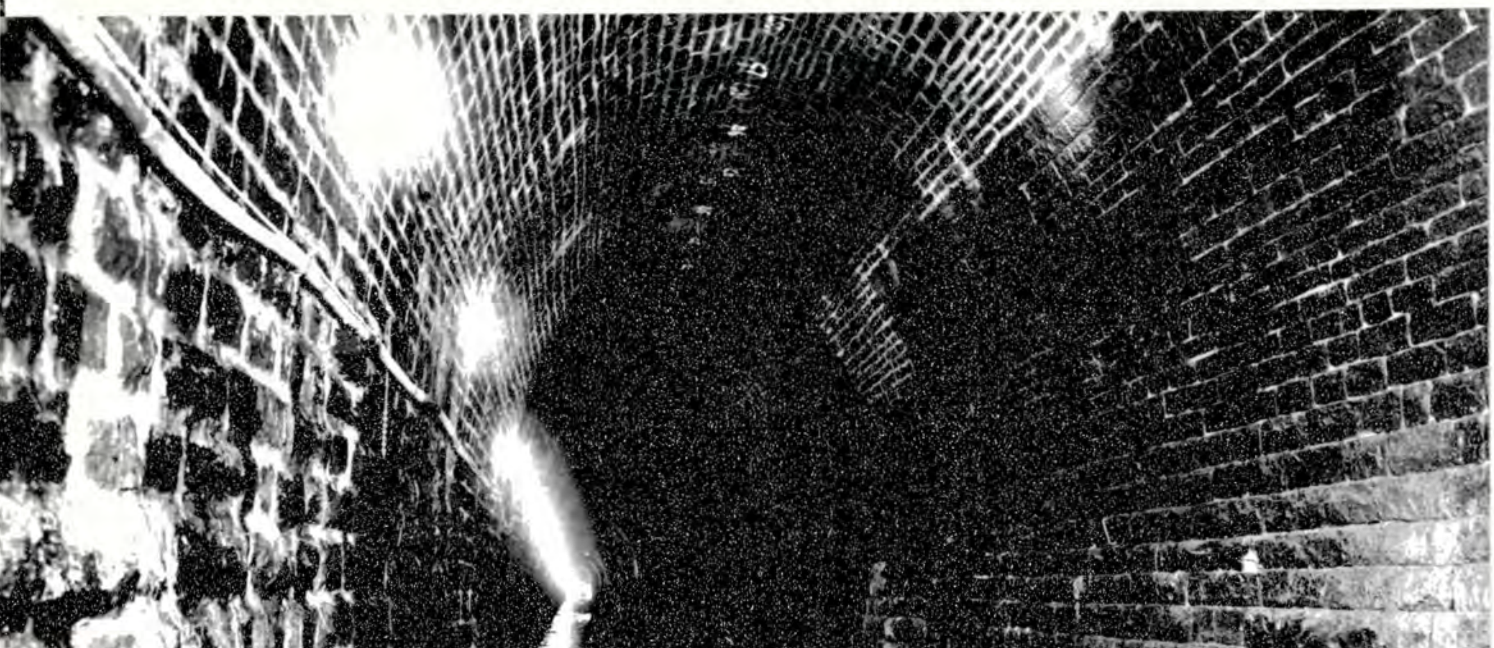
By using the tunnel the Generating Board have saved about £2 million if undergrounding was essential; or spent £2.5m unnecessarily to preserve the scenic grandeur of 3.6 miles of the bleak Pennine moors, if an overhead line could have been accepted.

Oxford

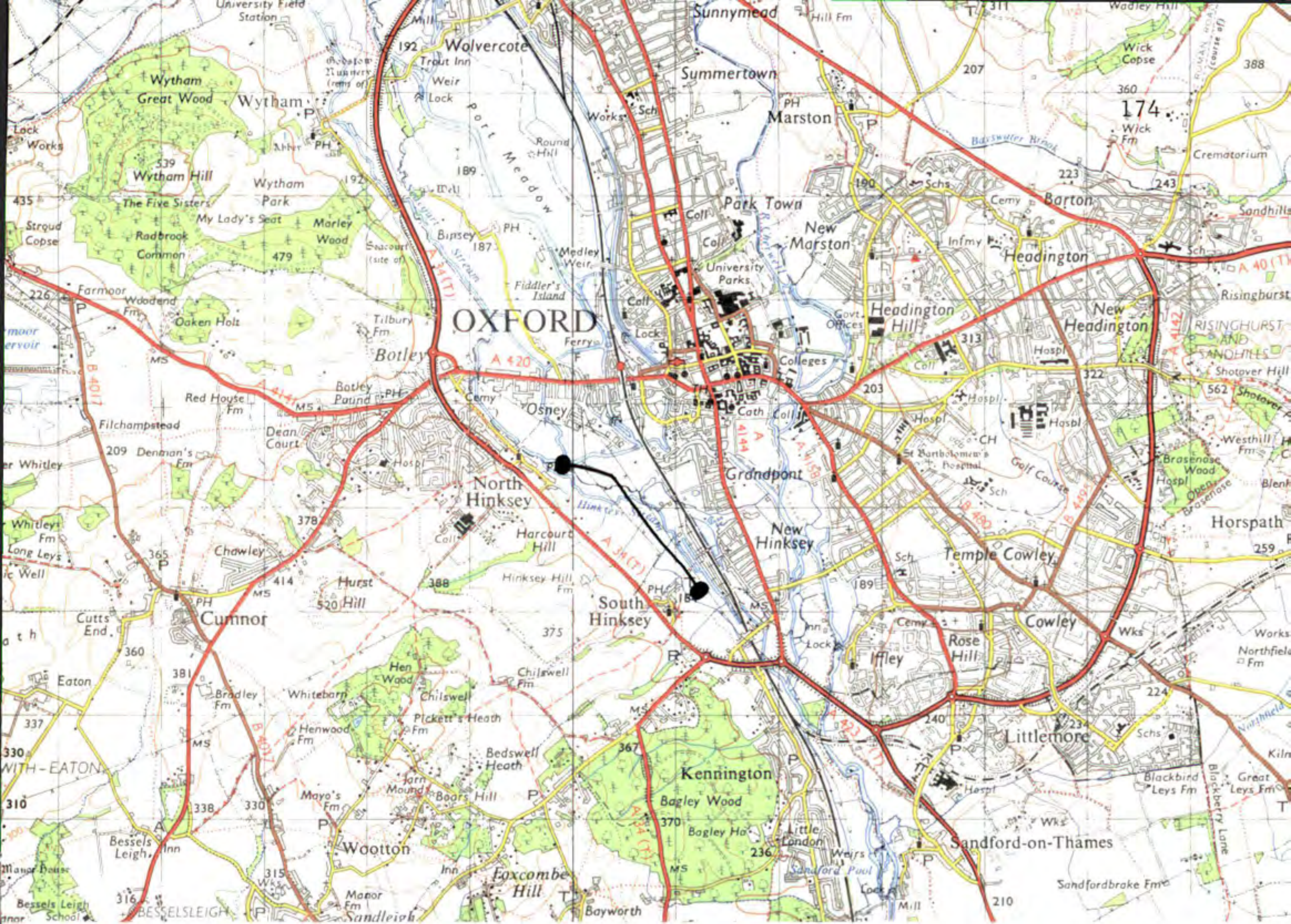
Following discussions with the Oxford City Council, the Board acceded to their request to underground a mile and a half of the Cowley to Seven Springs 400 kV line between North Hinksey MR 498058 and South Hinksey MR 511042 on the south side of Oxford. This underground section which will cost some £1½ million is being undertaken to preserve the famous view of the 'dreaming spires' of Oxford from Boars Hill and



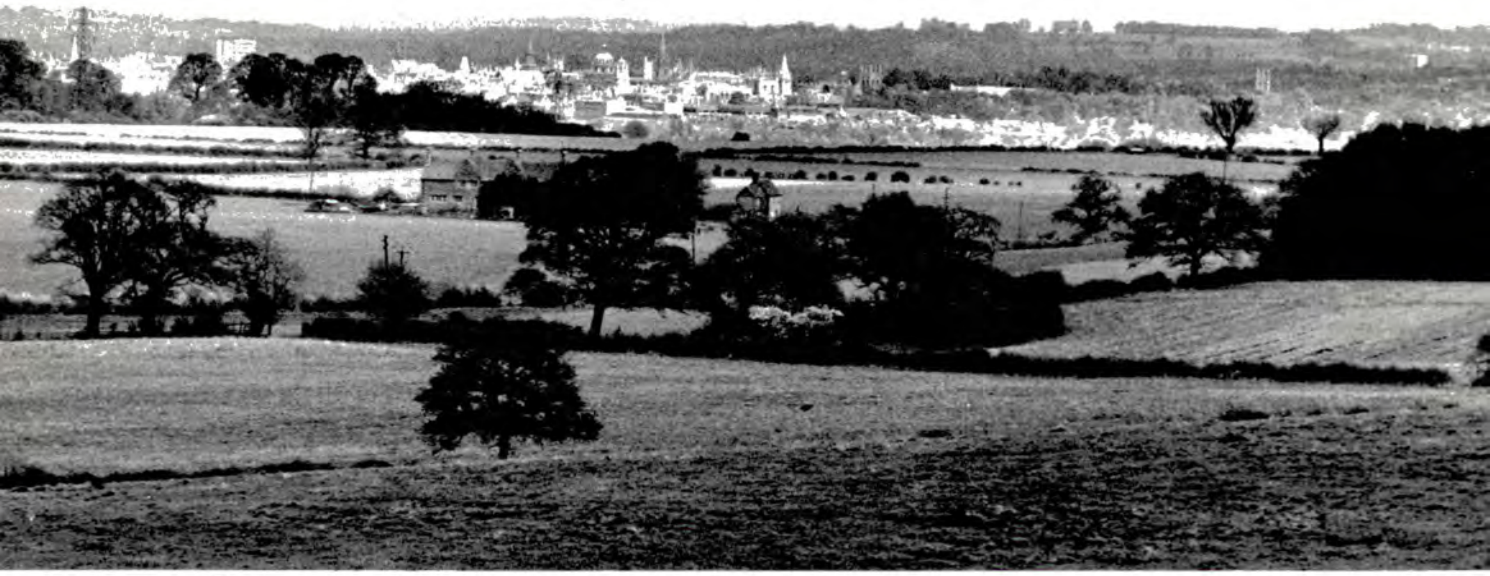
Map 27. Route of 400 kV cable through the disused Woodhead railway tunnel between Dunford Bridge and Woodhead.



Photograph 31. The tunnel after cleaning, repointing of masonry and brickwork, relaying of floor and installation of miniature access railway. The next stage will be placing of concrete troughs and laying of the 400 kV cables.



Map 28. Route of 400kV cable between North and South Hinksey at Oxford.



Photograph 32. View of Oxford from Boars Hill that has been preserved by cabling between North and South Hinksey.

and Rayleigh Park. The Board says it has decided to lay the cables underground "because of the unique character of these views". (56)

Southampton Water

A 400 kV connection was required between Fawley generating station on the west side of Southampton Water to Lovedean substation sited some ten miles to the north. There were three possibilities for making this connection. Firstly an overhead line travelling westwards, then around Millbrook to the north of Southampton and thence to Lovedean, but this was rejected from considerations of routeing and amenity.

The second possibility was to construct an overhead line across Southampton Water. It was unquestionably the shortest route, and although the towers would have been higher at any other river crossing in the United Kingdom, such a scheme was both technically and economically feasible. But the following discussions with Government departments and local authorities, the Board agreed to an underwater crossing mainly for amenity reasons. This led to the choice of the tunnel which not only preserved the shortest route, but overcame most of the amenity objections. The two mile tunnel runs from Fawley to Chilling M.R. 103870 shown on Map 29 and is now nearing completion. It is estimated to have cost the Board about £3 million. (57)

Goring Gap

The Board had engaged Miss Sylvia Crowe to advise them on the route of a proposed 400 kV line from Cowley near Oxford to Fleet in Hampshire, and particularly for the short section where it crossed the Thames, which is in an area designated as an Area of Outstanding Natural Beauty. Miss Crowe advised the Board that the line should be undergrounded through the Goring Gap but the Board rejected her advice because of the high cost it claimed would be involved in this operation. (58)

Map 29. Route of 400 kV cable tunnel under Southampton Water between Fawley Generating Station and Chilling.

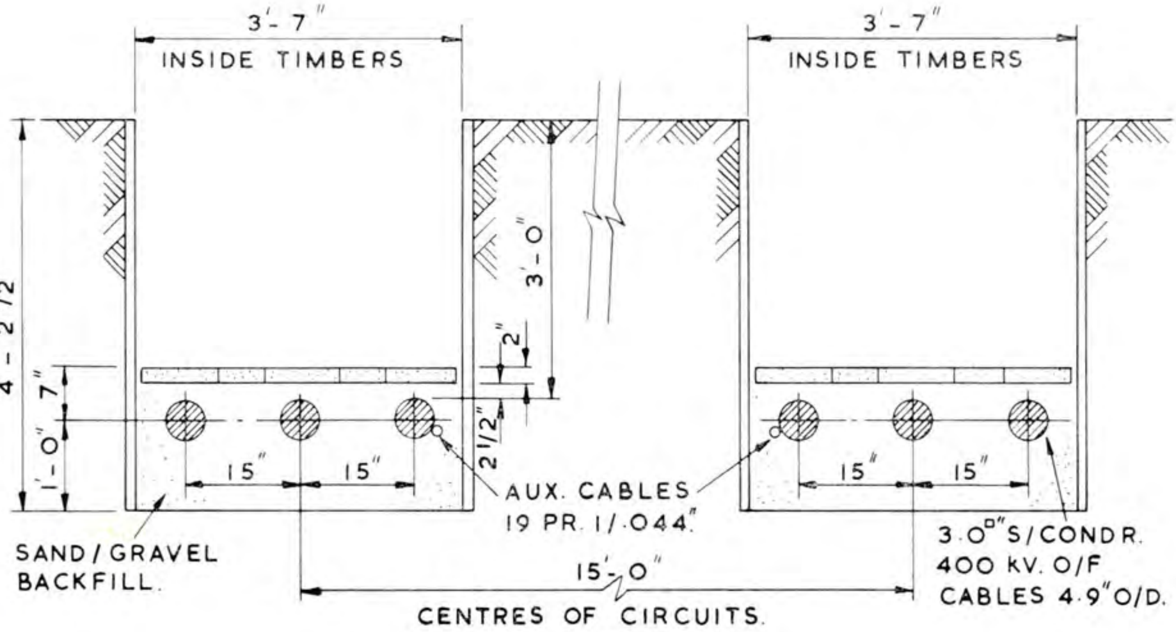
Photograph 33. Southampton Water cable tunnel before installation of cables.

Following a nine day public inquiry at Reading in 1965 the inspectors recommended an overhead line but, the Minister of Power, Mr. Richard Marsh rejected their recommendation and withheld consent for the section across the Berkshire Downs near the 'Goring Gap' (59) as requested by the Berkshire County Council and supported by the Council for the Preservation of Rural England (60) and the National Parks Commission. (61) The Board has now recognised that to complete the connection from Cowley near Oxford to Fleet in Hampshire it will be obliged to underground approximately 18 miles through the Berkshire Downs.

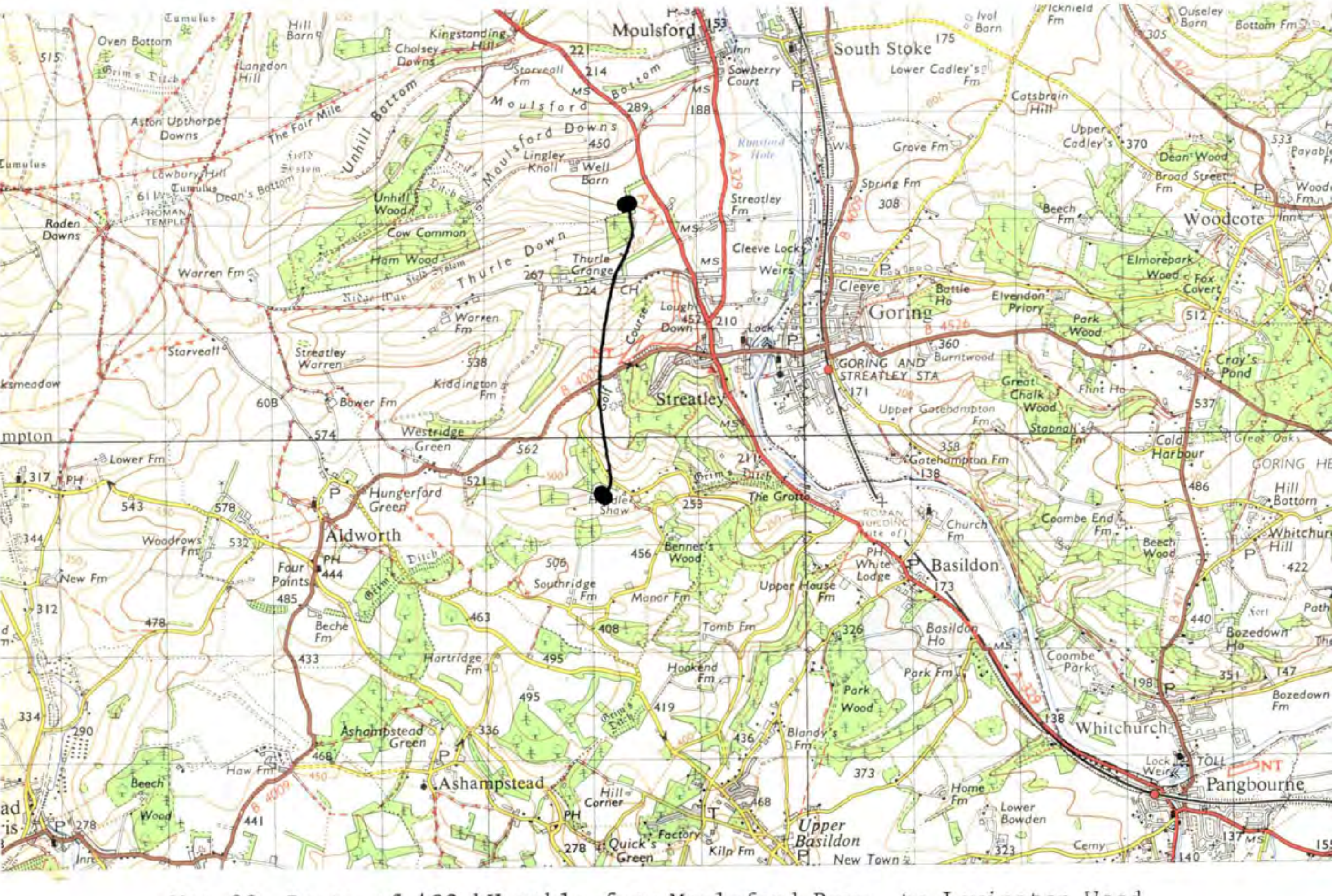
The positions of the sealing end compounds from which the cables run are at Moulsford Down M.R. 583822 and Lewington Wood M.R. 582796, and were virtually fixed as a result of the inquiry, and the cable route therefore became the shortest practical route between these points. Much of it lay over steep gradients, crossing a golf course, the corner of a wood, arable land and a farmyard. The route is shown on Map 30. The Board anticipated that for some years the electrical demands on this route could be met by cable having half the capacity of the associated overhead line, but provision was made for laying further cables as required. To ensure adequate dissipation of heat from the cables, and to avoid the use of a cooling water installation, the cables were laid far enough apart so that the dissipation of heat from one cable would not affect the others. The trenching arrangement is shown on the accompanying drawing. The cable was tested on 21st October, 1968, and has been estimated to have cost approximatley £1m.

Thames tunnel

As part of the 400 kV supergrid system in south east England the Board required a connection between Kingsnorth power station on



Drawing 4. Normal trench cross section for 400 kV cable installation at Streatley, Berkshire (62)



Map 30. Route of 400 kV cable from Moulsford Down, to Lewington Wood, Streatley, Berkshire.

the south bank of the Thames, to Tilbury power station in Essex on the north side of the river. The approximate length of the line would be about 10 miles, and required a crossing of the river. An overhead crossing was technically possible but would have involved expensive tower foundations. The towers would also have to be about 300 ft. high so that the sagging conductors would provide clearance for the masts of the tallest ships under conditions of the highest tides. The Board anticipated that there would have been strong amenity objection to such a proposal and they have said that the difference in cost between a high crosssing and a tunnel installation was small, and therefore a tunnel was adopted. (63) Work started on the 5,200 ft. long tunnel in January 1967. (64)

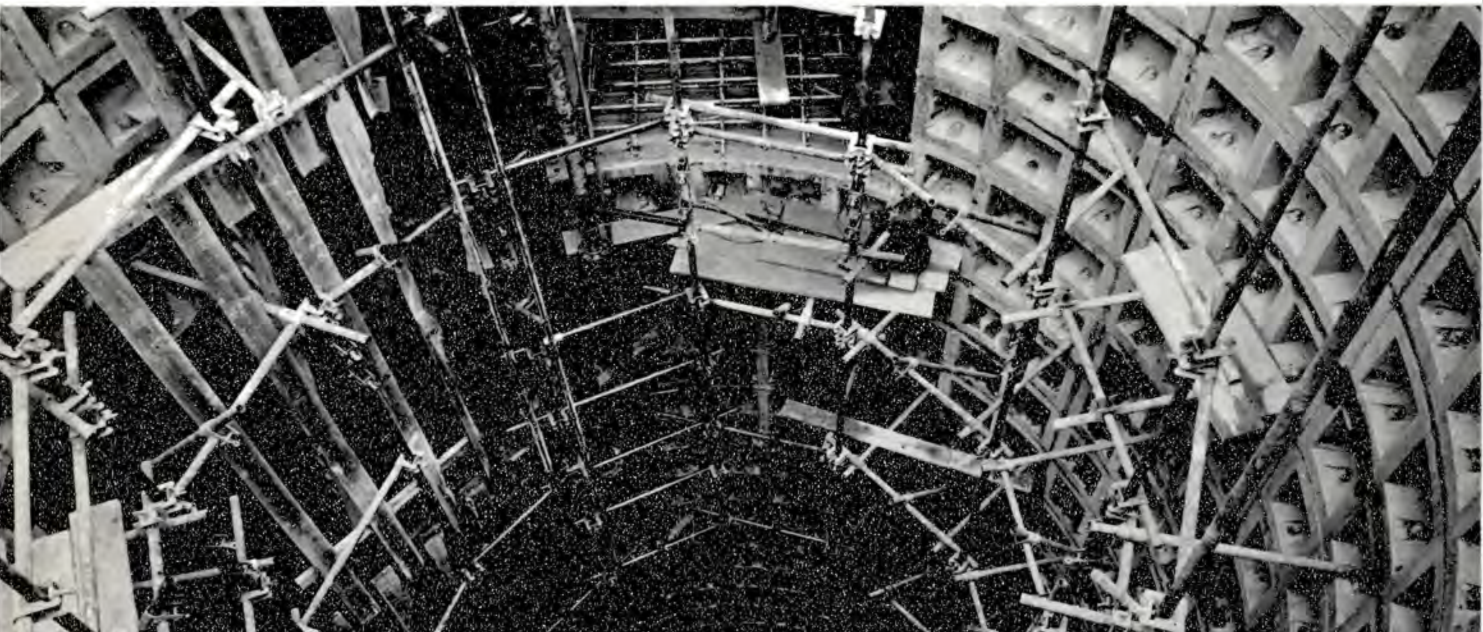
Ross-on-Wye

As part of the main transmission system for the south west and South Wales, a 400 kV route was required between Gloucester and Ystradgynlais in Glamorgan.

Originally plans were made for a connection which would be carried entirely overhead, but as a result of objections to parts of the route a public enquiry was held in July, 1965. (65) Further investigations were ordered in 1966, and in April, 1967, the then Minister of Power, Mr. Richard Marsh, required the Generating Board to place underground a section of the route " . . . to preserve the amenities of the river and the view from Goodrich Castle". The Minister's decision also tied down fairly closely the positions of the two sealing end compounds.

The cable runs from Brelston Green M.R. 563199 to Walford M.R. 584212 shown on map 32. This crosses a most beautiful part of the River Wye, and the Board is now in the process of laying the cable between these points. The cable route is approximatley 1.6 miles long over which cables having a capacity of half the overhead line are being installed initially. Provision is being made, for increasing the

Map 31. Route of 400 kV cable tunnel under the River Thames between Tilbury and Gravesend.



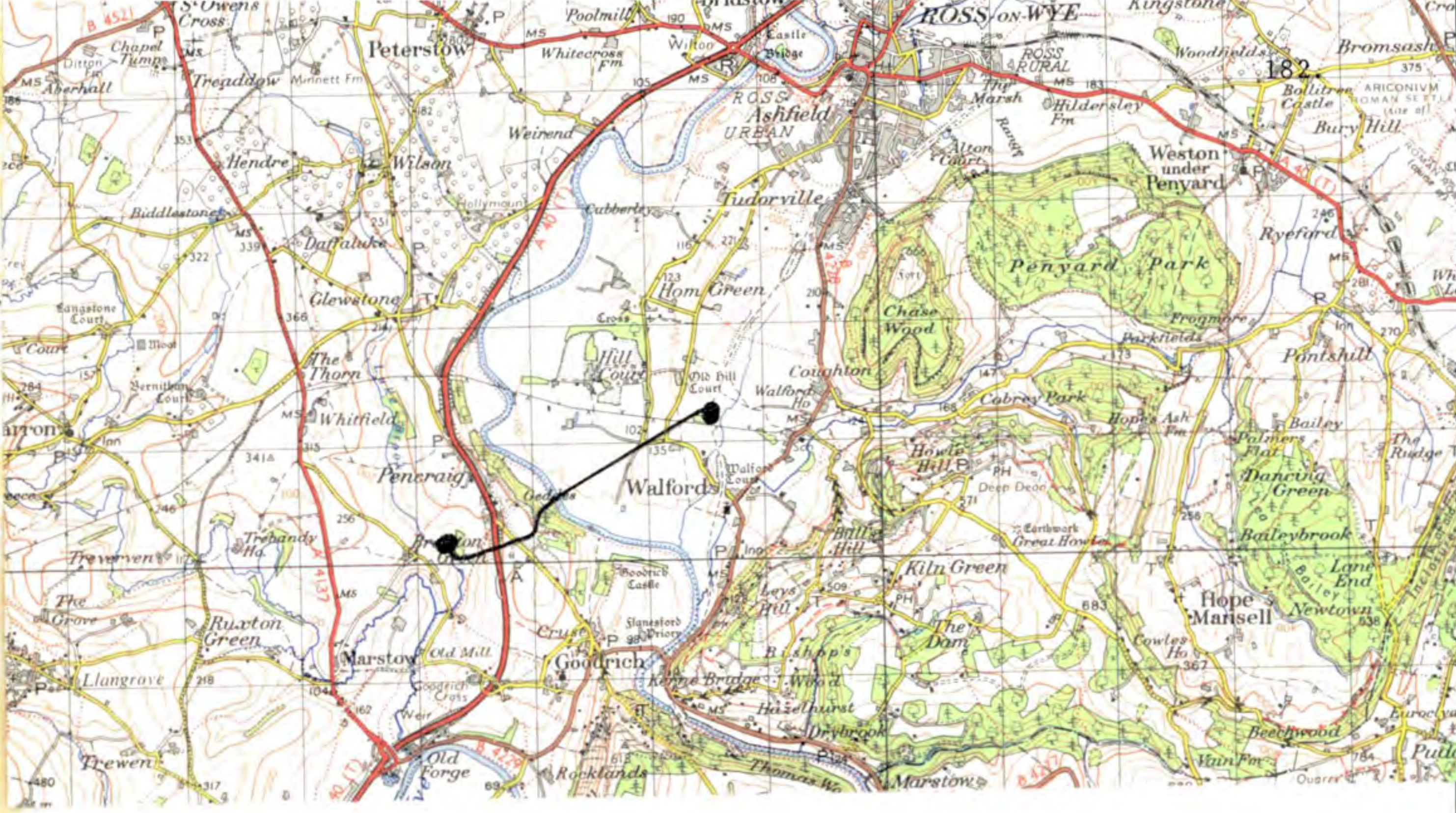
Photograph 34. Vertical cable shaft at Tilbury under construction.

capacity to the full rating of the overhead line circuits at a later date.

The western sealing end compound at Brelston Green lies in the valley of the Luke Brook to the west of the A40 trunk road from which the compound is screened by trees. From the compound the cable route rises steeply across pasture land and an orhcard. Throughout this section of the route the cables are laid direct in the ground with three cables buried 4 ft. 3 ins. deep in each of the two trenches. Normal cultivation is possible over them, except at joint positions where there is a comparatively shallow depth of soil.

All trees are removed from the route of the cables to avoid possible damage to the cables either by the tree roots or by the disturbance to the ground caused by a tree being uprooted. Trees are also cleared to avoid the danger that would be caused by the removal of moisture from the soil by the roots which would leave the cables in a dry, thermally unstable ground. After passing through an orchard, the cables pass under the A40 trunk road by means of ducts, and then proceed through a section of park land. This is the highest point of the route, and the cable after crossing a minor road the route enters the top of a gulley leading down to the river Wye.

At the top of the gulley the method of laying is changed to precast concrete troughs laid flush with the ground surface. This method of laying reduces the overall width required for the cable installation since the cables are laid closer to the surface and the heat generated in the cables can be dissipated to the atmosphere more rapidly. The use of troughs down the gulley does also have the advantage that it reduces the amount of tree felling that would have been necessary with cables laid direct in the ground, and also provides



Map 32. Route of 400 kV cable across the River Wye between Walford and Brelston Green.

Photograph 35. Installation of concrete troughs for 400 kV cables at approach to the River Wye.

a convenient method of locating an access road down the steep slope to the river crossing works themselves, as shown in photograph 35. (66) The cables are carried across the river Wye in PVC pipes embedded in concrete some 1 ft. 6 in. below the bed of the river.

At the boundary of the flood meadow and the cultivated land the cables again revert to laying direct in the ground. The route is comparatively flat from this point to the Walford sealing end compound where it has been positioned behind a small copse to give some screening of the structures when viewed from the high ground around Goodrich Castle. Undergrounding this 1.6 miles section of the 73 mile Gloucester-South Wales connection will involve an initial cost of approximatley £990,000 and an ultimate cost of £1,700,000 compared with £100,000 for putting this section of line overhead.

Severn Tunnel

A tunnel is to be built about two and a quarter miles long under the rivers Severn and Wye. It will run from just north of Aust,

Map 33. Route of proposed 400 kV cable tunnel under the River Severn between Aust and Caldicot Level.

to the tip of the Beachley peninsular and under the Wye to Newhouse as shown on the accompanying map 33. The tunnel is required to carry the 400 kV power line across the Severn as part of the route linking Melksham substation in Wiltshire with Cilfynydd in Glamorganshire. The tunnel will be about two and a quarter miles long, and with the cable will cost about £5m.

From a study of these eight schemes (67) one is left with the feeling that the total amenity expenditure for 400 kV undergrounding of about £16 million over a period of five years, when the total transmission expenditure has been in the order of £100 million a year is not unreasonable. A commitment of about 3% to preserve the views of Snowdon, Oxford, the Berkshire Downs, The Solent, The Thames, Rivers Wye and Severn and a part of the bleak Pennine Moors, would appear under these rather exceptional circumstances to be justified.

6.9 Conclusion

The Government's present attitude to high voltage undergrounding was stated quite simply by Richard Crossman in May, 1965 (68) when he said that the Government was not prepared to support extensive undergrounding because public opinion was not ready to pay the extra cost which would fall upon the consumer, and who would doubt that the vast majority of consumers would regard £1 million a mile for electric cables as a price too high to pay for preserving the countryside? The position would not change until a public opinion with a full understanding of the costs and technical problems involved, demand that the politicians spend the vast sums required.

There can also be little doubt that the Board would be glad to find a practical alternative to high voltage overhead transmission lines. Objections to its proposed routes consume an immense amount of time, money and energy, and the Board must be hoping for a major advance in cable technology that would make undergrounding less costly. In the meantime however, the Board would gain rather more public understanding of its difficulties if it would adopt an attitude of seeming to share the problem instead of appearing to confuse the public by ambiguous and conflicting statements. With this objective the following actions could be recommended which may help to achieve a greater appreciation of the Board's problem of deciding when, and when not to undertake the expense of major undergrounding.

1. A nationally respected independant body or special Commission to investigate cable costs, and publish a report explaining how and why high voltage cables are so expensive and make comparisons with the costs of the same capacity cables in other countries.

2. The appropriate Government department should publish the amount of money spent each year on cable research, with some indication of the possible results, and the Board should be encouraged to pursue with determination current research programmes designed to bring down the cost of underground cabling.

3. The Board has frequently stated its willingness to underground 132 kV line entries into substations and it would provide more credence to the policy if the next Annual Report would mention those specific cases when this has been done.

4. Publish annually the amount of money spent on cabling and refer to all those cases where cabling has been done solely for amenity reasons.

5. Establish a standing committee to conduct local surveys, both in areas where lines are due to run and elsewhere, and discover how strong and reasonable public opposition is to the Boards developments. Also to inquire how much expense people are prepared to go in order to

reconcile the provision of electricity with the retention of amenity. This committee to make recommendations and to keep the problem under review yearly.

With these facts the interested inquirer could see how much the Board, and indirectly the nation, pays to preserve amenity, and to judge for himself whether such expenditure is in the intent and spirit of the Board's statutory obligation to pay due regard to amenity. If one were uncharitable one might think that the Board deliberately withholds this information, as it would not wish to publicise its own shortcomings. On the other hand, it is possible that the Board has not correlated this information, in which case it should do so in order to evolve their own policy. Whatever is the truth of the matter the Board should be obliged to declare the facts of the situation, so that a clear national policy could be discussed, agreed, and applied.

CHAPTER SIX

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12. C.E.G.B. Annual Report 1964 Page 6 also Power Progress No. 7 October 1965.

13. Power News. September 1964.

14. The Proceeding of the Thirteenth British Electrical Power Convention Eastbourne. The British Electricity Transmission System, a paper read by Sir Christopher Hinton Chairman C.E.G.B. Tuesday 13th June, 1961 Page 43 also quoted to the Select Committee on Nationalised Industries 28th May, 1963, Volume 1, Page 159, Paragraph 514. An apparent inconsistency is noted in respect of the length of motorway that could be constructed for an equivalent length of 400 kV cable. This may be explained if Sir Christopher had in mind 2 x 0.4 circuits and the previous reference was to 4 x 0.4 circuits. See table 3 for respective costs.

15. Why not Underground. C.E.G.B. publication May 1965. An open letter by Mr. John Sykes, an electrical engineer (well known for his writing and broadcasts on electrical matters), who is often asked questions about the need for Grid transmission lines and why they cannot by undergrounded.

16. Power and Pylons. C.E.G.B. News Letter No. 58 October 1965 reprint of an article by the Right Hon. William F. Deedes M.C., Member of Parliament for Ashford, Kent, which appeared in the "Kent Messinger" and the "Tonbridge Free Press" of 3rd September 1965. The article discusses the effect of the Board's programmes on the countryside.

17. The Pylon Row. C.E.G.B. News Letter No. 64, February 1966, reprint of an article by Edward Hyams which appeared in the "New Statesman" of 10th December, 1965.

18. Answer to a question given by Mr. John Morris, Parliamentary Secretary to the Minister of Power in the House of Commons on 16th February, 1965. Hansard Vol. 706 Col. 985.

19. The 400 kV Supergrid and its Capacity op.cit.

20. C.E.G.B. Annual Report 1964-65, published 4th August, 1965, Page 7.

21. Power News June 1965, also in C.E.G.B. Annual Report 1964/65 Page 27.

22. Power Progress No. 7, October, 1965.

23. C.E.G.B. Annual Report 1966/67 Page 18.

24. Power Progress No. 9 Page 30, also C.E.G.B. Annual Report 1966/67 Page 4.

25. Herbert Report, H.M.S.O. 1956 Command 9672. Appendix F Page 168.

26. Power Progress 1959/60, C.E.G.B. publication.

27. B.E.P.C. 1961 Eastbourne op.cit.

28. C.E.G.B. Annual Report 1963. Page 8.

29. The Architecture of Power, exhibition brochure 8-30, March 1963.

30. Select Committee on Nationalised Industries Vol. II, Page 119, Para. 981.

31. House of Lords Official Report, Hansard 16th February 1965. Volume 706, Column 985.

32. C.E.G.B. Annual Report 1965, Page 35.

33. The British Association for the Advancement of Science Aberdeen Meeting 1963.

34. Financial Times, 10th November 1964, also Proceedings of the Institute of Electrical Engineers, September 1966, Page 1509.

35. This drawing is reproduced from Estates and Wayleaves Bulletin No. 9 published C.E.G.B. April 1968, also published in the Birmingham Post 30. 9.68 to illustrate an article, "Solution to a Problem of Ugliness?" by Ian Hamilton Fazey.

36. Times, 5th December, 1967.

37. House of Commons Official Report Hansard, 4th August, 1965. Vol. 717, Col. 1717.

38. C.E.G.B. Annual Report 1966/67, Page 4.

39. C.E.G.B. News Letter No. 69, October 1966. U.S. Report on Undergrounding cable costs higher than in Britain.

40. Report on the Electricity Supply Industry in England and Wales, 1966/67 published by The Electricity Council. Total expenditure on research in 1966/67 was £10.6 million, of which about £167,000 represented contracts with universities and colleges of technology. Research expenditure in the previous year was £9.1 million.

41. This public Inquiry was held on the 24th and 25th November, 1964 before Mr. Baldock, an inspector of the Ministry of Power and Mr. Roberts, an inspector of the Ministry of Housing and Local Government, to consider objections against the proposed 400 kV line from Cowley near Oxford to East Claydon, Buckinghamshire. Times, 25th November, 1964. The Guardian, 25th November, 1964.

42. Engineering 25.12.64. Eastbourne Herald Chronicle 26.12.64. Devon Express and Echo 6.1.65. Peterborough Evening Telegraph 25.1.65. Leamington Morning News 1.2.65, and many others.

43. C.E.G.B. News Letter No. 47, December 1964, and C.E.G.B. News Letter No. 64, February 1966.

44. Hansard, House of Commons reports 22.1.65. Vol. 705, Col. 655. This debate was in connection with a proposed 400 kV line from Lydd to Bolney, but the Board's evidence given at Waddesdon was challenged by Mr. P. Horden M.P. and defended by the Parliamentary Secretary to the Minister of Power.

45. Sir Herbert Griffin the General Secretary of the C.P.R.E. had a letter published in the Guardian 17. 2.65 expressing concern that the Parliamentary Secretary to the Ministry of Power had appeared to accept the Board's evidence so uncritically as established and unanswerable facts C.P.R.E. Annual Report 1964/65, Volume XVIII No. 1, Page 10.

46. Two short lengths at Lydd and Eggborough had been commissioned, and are on Board operational land, and have been ignored in the context. The Glaslyn Estuary cable was operating under test, but not commissioned.

47. It must be acknowledged that the Glaslyn Estuary cabling is close to Snowdonia National Park, and the cabling being done at the Goring Gap is near the Chilterns Area of Outstanding Natural Beauty.

48. C.E.G.B., Annual Report, 1963/64 Page 31.

49. National Parks Commission Annual Report 1963, Page 31.

50. C.E.G.B., Annual Report 1962/63 Page 7.

51. National Parks Commission Annual Report 1963, Page 31.

52. The public enquiry was held at Barnsley in October 1963.

53. This was one of a pair of single line railway tunnels driven in the mid-19th Century for the Manchester to Sheffield railway line, which had been replaced by a larger tunnel on electrification of the line in 1954.

54. C.E.G.B. Annual Report 1965, Page 25. Contract Journal 1.8.68. Page 521.

55. C.E.G.B. Annual Report 1966/67, Page 18

56. Gloucesterhsire Echo, 21.4.65, Oxford Mail 18.8.65, North Berks Herald 22.4.65 and 19.8.65.

57. C.E.G.B. Annual Report 1966/67, Page 18.

58. Reading Standard 13th November, 1964.

59. Times Page 6, Telegraph Page 23 and Oxford Times 22nd April, 1966.

60. C.P.R.E. Annual Report 1964/65 Volume XVIII No. 1 Page 12 also C.P.R.E. Annual Report 1965/66 Volume XVIII No. 2 Page 20.

61. National Parks Commission 17th Report for year ending 1966, Page 34.

62. Drawing based on one published in "Span" the house magazine of the C.E.G.B. Transmission Project Group, Vol. 5 No. 3 Page 8. December 1968.

63. "Span" op.cit. November 1968, Vol. 5. No. 2, Page 8.

64. C.E.G.B. Annual Report 1966/67, Page 18.

65. This inquiry took place at St. Joseph's Convent, Walford Road, Ross-on-Wye on 27, 28, 29 and 30th July, 1965, concerning the route of the proposed Gloucester - Ystradgynlais 400 kV line. This inquiry was widely reported in the local press, and a good summary appeared in the Monmouthshire Beacon 6.8.65.

66. This illustration is taken from "Span" the Transmission Project Group House Magazine July 1968. A similar but somewhat earlier illustration was published in Circuit News July 1968.

67. The Board has been investigating the possibility of siting a power station at Portland. At a public inquiry at Weymouth in November 1964 concerning the route of the proposed Mannington - Exeter 400 kV line the Board had said that if the power station scheme was approved, then the Board would be prepared to place underground the 3.5 miles, 400 kV connection to Chickerell Substation.

68. Richard Crossman Minister of Housing and Local Government addressing the National Federation of Women's Institutes at the Albert Hall, London, on Tuesday, 25th May, 1965.

CHAPTER SEVEN

Case Study - Bradford to Darwen 400 kV line.

7.1 Introduction

Sometime in 1961 the Generating Board decided that it required to bui a 400 kV line across the Pennines from Bradford in the West Riding of Yorkshire to Darwen in Lancashire, via Padiham. They recognised that to find a route across the Pennines through an area associated with the Bronte sisters, and through countryside of great character and beauty would present considerable problems. Apart from the basic amenity difficulties, many others became apparent during the course of the Board's negotiations. This case study has been undertaken not from a political, administrative, or policy point of view, but in order to consider how the engineering and wayleaving criteria mentioned in a previous chapter are applied in one particular instance. It is not thoug that the history of the negotiations for this line is necessarily very typical, although it is not exceptional; and of course not all engineering and wayleavin problems are evident in this case. The fact that this line involved two public inquiries, was partly the reason for choosing it as a case study. Every mile o the line had been subjected to detailed examination, cross-examination and the balance of advantage and disadvantage carefully weighed and decided. As all this is fully documented it provides accurate material for this study. (1)

Note:- Map 34 showing the alternative routes discussed in this chapter is included in the pocket at the back of this volume.

7.2 Preliminary Negotiations

The Board required to construct a 400 kV line from a point near Bradford in Yorkshire westwards across the Pennines to another near Darwen in Lancashire. In a direct line this would be a distance of about 25 miles. The line was planned to form part of the national supergrid, and was required for two purposes. Firstly, it was to transmit surplus power from the Yorkshire generating stations on or near the Yorkshire coalfields at Thorpe Marsh, Ferrybridge and Eggborough, to Lancashire, where the expected demands could not be met by local power stations nor with the addition of imports of power available from the nuclear generating stations in North Wales. Secondly, the line was to provide secure transmission connections as part of the supergrid from the large sources of generation in the Yorkshire, North East and East Midland areas. At a later date the line was intended to provide additional electricity supplies to satisfy future increases in the Burnley, Padiham and Blackburn areas. The Board estimated that the demand in the Burnley, Nelson and Colne areas would require reinforcement in about 1973. The Board proposed to provide a 132 kV supply from the supergrid system, and they claimed that the logical position for the new supply point would be Padiham which was already the focal point of the secondary transmission system in that area. For that reason the line the Board proposed was routed via Padiham rather than the direct route between Bradford and Darwen.

In designing a transmission system there are two aspects to consider in determining the route for a line. Firstly; the immediate future, where the pattern of load and generation are defined within reasonably close limits, and secondly; the period beyond ten years when the load and generation are less well defined and are more subject to change.

The route that offers the best chance of meeting both of these conditions should be adopted. The first route proposed by the Generating Board crossed the Pennines to the north of Boulsworth Hill as shown in red on the map. This line would meet the electrical requirements of the immediate future and barring radical changes in electricity supply policy would meet the Board's requirements for at least ten years. For the future the Board were almost certain that the total mileage of transmission circuits in the area would be less if that route were chosen. However, in deference to the view of the Lancashire County Council, the Board proposed an alternative route for a section of the line from a point south-east of Burnley running in a general north-easterly direction across Wadsworth Moor, which was investigated. This route is shown coloured blue on the map. In about September, 1965 application was made by the Board to the local planning authorities for both the original route and the alternative, with an expressed preference for the northern red route.

There was opposition to both routes. Neither was supported by the Lancashire nor the West Riding County Council, but in considering the route of this line, they invited the Board to consider a third alternative further south than the other two, coloured green on the map. The Board regarded this third route as practicable, and asked the Minister of Power to consider this route concurrently with the others.

Several meetings were held between the Board and the Local Authorities, but it seems that every alternative had its advocates and objectors.

As there was no consensus of preference and agreement could not be reached the Minister of Power decided to hold a public inquiry to determine the matter.

7.3 Public Inquiry

The public inquiry was held at Keighley in July, 1966 when the advantages and disadvantages of the red, blue and green route were publicly argued. (2)

The Generating Board explained that the line was required to transmit surplus power from the Yorkshire generating stations to Lancashire, to form part of the national supergrid and, subsequently, to meet increased demand for electricity in the Burnley, Padiham and Blackburn areas. The Board had applied for one of three routes across the Pennines, and a section common to all three from Hapton Clough to Darwen.

The Board's witness said that by adopting the red route there would be three fairly evenly spaced main transmission Yorkshire to Lancashire 400 kV lines through the densely populated West Riding and East Lancashire areas. All existing and new urban development in the area would be reasonably near a main trunk line which would be conveniently tapped with the minimum length of additional line.

The red route was within relatively easy reach of the public roads and the problems of access for construction were no more hazardous than with the average line. The blue route although shorter than the red route crossed very open inaccessible country for some 9 miles, 4.4 miles of the route would be above 1,200 ft. and because of wind and ice loading conditions experienced at that height the maximum span would need to be reduced to 800 ft., the effect of that being to increase the number of towers by 40%.

The 4.6 miles of the green route above 1,200 ft. would be treated in the same way. The Board indicated that operational experience of a line similar to the blue route might cause the Board to reconstruct the higher section over the moors as two single circuit lines.

If the blue route were adopted the Board thought that the period when construction could take place would be limited by the very adverse weather conditions experienced during the winter months. The commissioning of the line might for that reason be delayed by a year. Extra care would be also be necessary during wet weather in the summer months so that the top surface of grassland would not be permanently damaged; special vehicles with low ground bearing pressure would have to be used. The moorland section of the green route crossed country similar to the blue route but the access would be less difficult. Access to the remaining parts of the green route should not present any undue difficulty. From geological survey maps available there were stretches of each of the routes where bad ground conditions such as peat would be encountered. The worst route affected was the blue route followed by the green route whilst the red route would be affected for a short section only. In a long dry summer the Board said that the blue route would be as easy to construct as the green route although these routes would always be more difficult than the red route.

No points of special engineering difficulty had been mentioned by the Board on the red and blue routes except that on the blue route there was the general difficulty of access for construction over the moors. There were, however, five places of particular difficulty on the green route. (3)

All three routes were subjected to objection and it seems that it would have been impossible for the Board to have selected a route which would have satisfied all the objectors. Different parties set different values for different types of amenity. The Board said that they regarded it as their duty to weigh carefully all the conflicting interests. A route in the valley had been welcomed by some as the effect of the line would be localised, but it would cause strong protest from others whose homes would become more closely affected. To place the line on the lower slopes of high moorland to clear a residential area had the advantage of providing a background for the line as seen from places where people live, but it would be objected to because it would lie between those people and their recreational access to the moorland and other places of interest. The moorland area itself was unpopular as a location for the line because it was high, exposed and its beauty was at present largely unspoilt.

Objections covered all types of country available for the line and the Board were faced with the problem of deciding which objections carried greater weight in the general public interest. In the light of conflicting observations received, it appeared to the Board that the balance in favour of one type of amenity over another was not overwhelming,and they had therefore decided that they should apply to the Minister for such reasonable and practicable alternatives as had been put to them by interested authorities.

In addition to the red route which was the Board's preference, the application covered the blue route because it was suggested by the Lancashire County Council as improving the situation for people in the Colne, Nelson and Burnley conurbation and because it offered a route some three miles shorter than the red. The green route had been adopted because it was the combined suggestion of the County Planning Officers of Lancashire and the West Riding of Yorkshire supported by the National Parks Commission, (4) and also because it avoided the problem of the Bronte country.

The Board summarised their case by saying that the most northerly of the three routes, the red route, would be within comparatively easy reach of roads and keep generally on lower ground than the other two. It would thus be the least difficult to construct and maintain. The middle blue route crossed high inaccessible country for some 9 miles, of which $4\frac{1}{2}$ miles would be over 1,200 ft. The third green route would also run for about $4\frac{1}{2}$ miles above 1,200 ft. and the two latter routes, particularly the blue would be more exposed than the red to the effects of bad weather. The total route lengths from Bradford (Shelf in the case of the green route) to Darwen would be 33, 30 and 40 miles, and cost £2,231,000, £8,179,000, and £2,931,000 respectively.

In making alternative applications to the Minister it was the Board's practice to state a preference for one of the routes concerned. Having regard to the conflicting views on the amenity issue, the Board had based their preference primarily on the advantage which the red route offered because it would be easier to maintain and keep in service in severe weather when the line could be most needed.

It was the Board's view also that on balance the red route was to be preferred on amenity grounds as well.

The West Riding County Council said that as a result of long and careful consideration of all the facts involved and bearing in mind the various objections raised to parts of all the three routes, the Council, whose views were in agreement with those of the Lancashire County Council and the National Parks Commission, were of the opinion that the green route was the least harmful to the County as a whole. They were also supported in their view by the Keighly Borough Council, the Council for the Preservation of Rural England, the Hardcastle Crags' Preservation Society, the Civic Trust for the North West, the Ramblers' Association, the Bronte Society, the Haworth Civic Society, and numerous local societies and community groups in the Keighly area.

The County Council were very sympathetic to the views expressed by the three objecting West Riding local authorities of Brighouse, Elland and Ripponden regarding a line on the green route and recognised its effect upon them. Their points of view were very valid and while the County Council accepted that such a line would be very damaging in parts they believed that any neutral person would take the view that it would not be so damaging as would be lines on the red or blue routes to other parts of the West Riding. So far as the County Council were aware no country-wide amenity organisation objected to the green route.

The County Council had been forced to that judgement by three steps of reasoning.

Firstly, they had accepted the need for a further supergrid line across the South Pennines; secondly, the red and blue routes were unacceptable because they traversed open country of high amenity value much of it remote, wild and unspoilt to which large numbers of people were attracted either for recreational purposes or because of its literary associations with the Brontes; and thirdly, only the green route was acceptable on amenity grounds. Its advantages over the red and blue routes were that it traversed land of less scenic value and crossed the Pennine way where it was least used and close to both the existing Monk Fryston Rochdale 275 kV line and the Halifax-Rochdale Road, and also the A58, which carried a very large volume of commercial and industrial traffic. Because of its geographical position and the existence of the West Riding coalfield the County had accepted several large power stations, and the main transmission lines associated with them. The County Council considered that this entitled them to ask the Board to accept certain extra difficulties and some additional expense in order to preserve the natural beauty of the countryside. By so doing the Board would be having regard to their statutory duty under Section 37 of the Electricity Act, 1957. (5)

The County Council said that lines on the red or blue routes would cause permanent damage to an area of outstanding scenic value and unspoilt natural beauty which was much frequented by the residents of surrounding industrial towns in the West Riding and East Lancashire. Lines on either of those routes would encroach upon the Bronte Moors and pass close to the village of Haworth, to which it was estimated there were some 500,000 visitors each year, some 60,000 of whom visited the Bronte Parsonage Museum at Haworth.

The extra cost involved on the green route, £659,000 according to the Board, but only £580,000 by the County Council's estimate, was considered to be a reasonable extra expense in order to safeguard a large and regionally important area of high scenic value, which was also the second most visited literary shrine in the country. Lines on either the red or blue route would result in very much greater financial loss to the tourist trade in Yorkshire which it was hoped would reach £30,000,000 per annum by 1970.

The blue route had been the Board's first alternative to the red, and had been put forward following discussions with Lancashire County Council about the section of red route between Walk Mill to the south-east of Burnley and Water Sheddles Reservoir on the county boundary at the Herders Road. But Lancashire County Council had stated subsequently that they preferred the green route. The blue line would be the cheapest of the three alternatives, but since the Board's witnesses concerned with construction, maintenance and amenity, had stated that it was the least satisfactory of the three, it seemed that the real issue before the Minister was the choice of the red or green routes.

The County Council quoted the Board as saying that cost alone was not by any means a decisive factor, and that the Board's firm preference for the red route was based primarily on its reliability and, in particular, ease of access to the line for maintenance. The Board had placed those factors higher than those relating to cost, and appeared to have decided on such preference for the red route without having regard to the serious access problem which existed in the Forest of Trawden area generally, including the Herders Road, under wintry conditions.

The County Council said that in the winter of 1962/63 roads well below 1,000 ft. had been blocked by 20-25 ft. snow drifts for six to seven weeks, and that much of the red route was more than $1\frac{1}{2}$ miles from class A roads.

The Board had stated that in their experience about one-third of all faults in the North West Region occurred at about or above 1,000 ft. above ordnance datum and had produced figures claiming that the red, blue and green routes had respectively 3.5 miles, 9.1 miles, and 10.3 miles above 1,000 ft. The Council considered there was nothing special about the height of 1,000 ft. and a figure of 800 ft. would have been more appropriate having regard to the height of the towers. A considerable length of the red line was believed to be close to 1,000 ft. and much of that high ground was less conveniently situated in relation to access from class A roads than was the case with the green route.

In contrast to the Board who had said the balance of one particular line was not overwhelming, preferring the red on grounds of access and maintenance, the County Council asked the Minister to find there were overwhelming amenity disadvantages with the red and blue routes, because of the serious effect that lines on them would cause to an area or outstanding natural beauty with great public attraction. The Minister was also asked to support the County Council's view that the green line was the only one of the three alternatives submitted by the Board which could be accepted on amenity grounds.

There appeared to be general agreement among most of the other parties at the inquiry that the green route would be the least harmful to amenity. The County Councils, the National Parks Commission and many other authorities and organisations, urged that lines on the red and blue routes would cause permanent damage to areas of outstanding scenic beauty.

The red route would encroach upon the Bronte moors passing close to the village of Haworth which drew thousands of visitors annually. Access to the red route would be very much worse than to the green under severe weather conditions. Both the blue and the red routes crossed parts of the Pennine Way which were greatly used, whereas the green route crossed the least used section where scenic values had already been depreciated. The red and blue routes would also adversely affect the amenities of Towneley Park and Towneley Hall at Burnley which attracted many visitors each year.

Strong objections were, however, voiced to the green route. Brighouse Borough Council said it would traverse $3\frac{1}{2}$ miles of green belt which they had fought hard to preserve. Elland Urban District Council, who questioned the need for the line in view of possible nuclear power developments, considered that the green route had been hastily conceived and that the scenic values and literary associations of the red and blue routes had been over-stated. Elland already had more than its fair share of overhead lines, but if the line had to come, the Council would be willing to help in the provision of a route. Ripponden Urban District Council favoured the blue route as being the cheapest and affecting fewest people. The Halifax Gliding Club said the green route would be a hazard to gliders at Ringstone Edge Moor; if it could not pass further west and north of the moor, keeping below the 800 feet contour, the club would have to cease flying.

Blackburn County Borough Council objected to the line near the outskirts of the town, on the section common to the three alternatives, because of the possibility of future industrial and housing development.

Objections to all three routes were put forward by or on behalf of individual owners and occupiers of properties, local bodies or organisers of petitions, on grounds of amenity, depreciation in value of property, restriction of future development of land and interference with agriculture and grouse shooting.

7.4 The Inspectors' Conclusions

The need for the line had been accepted by all the objectors except Elland Rural District Council. The Inspectors thought it might well be that at some future date through advances in technology, there could be a change in policy whereby smaller power stations, possibly nuclear, were sited near load centres along the lines suggested in the Review of the West Riding Development Plan. Such changes, however, were not in the immediate future, and on the present showing the need for the line remained.

Of the three alternative routes the red traversed countryside of great character and beauty, large tracts of which were entirely unspoilt. The impact on the Bronte country and the Pennine Way would be severe. The country between Hanton Clough and the Forest of Trawden was very pleasant and the line would be seen from numerous public footpaths and minor roads.

The blue route was less harmful to the Bronte country than the red and its cumulative effect on amenities less severe. But it traversed even wilder and more remote moorland. It would have a greater impact on the Pennine Way and would be conspicuous at many points, particularly where it crossed the Keighley to Hebden Bridge Road, and in the Wadsworth Moor and Hardcastle Crags areas. The Inspectors considered this alternative unsound as the line would be virtually impossible to maintain at crucial times, they therefore considered that the red and green routes were the only sound proposals.

To strike a balance between all of the factors of importance on the red and green routes would be extremely difficult and they accepted that opinions on how much weight to attach to those factors can differ widely and at the same time be honestly held. They were, however, impressed by the strength of amenity opinion coming from the planning authorities, the National Parks Commission, the Council for the Preservation of Rural England and other organisations in favour of the green route. They accepted the point made by opponents of the green route that less publicity was given to that route than to the red or blue routes, but even if this had not been so they thought it unlikely that the balance of amenity opinion would have been much different. They believed that the Brónte country was of both regional and national importance, thus having a value also for opponents of the green route, and in the public interest should be harmed as little as possible. The Inspectors considered that the cost of preserving this area by adopting the green route would be formidable. The line itself would cost £700,000 more which with the necessary undergrounding of the Elland spur would rise to £909,000. The Board would not be undergrounding the Burnley spur so that the next extra cost would be £659,000. To this must be added firstly, the fact that the green line would be harder to maintain, secondly that its adoption would cause the system as a whole to be less satisfactory technically, and thirdly that reinforcement would be required earlier, between two and five years in the 1980s. In their opinion the cost of preserving the Bronte country and the nearby, much visited, moorland scenery traversed by the red line - heavy as it is - was justified in the national interest and should be met. It followed that the green route is without doubt their overall choice.

The inspectors thought that the needs of the Halifax Gliding Club could and should be met by an adjustment of the green route provided that any further damage to the amenities of Ripponden and Rishworth was not too great, but considered it unlikely that a more satisfactory route than the green could be found in the Elland area. They could not recommend the alternative suggested by the Calder Civic Trust and Calder High School Sixth Form Society (6) to the north of the red route because it would be very difficult to find a way through the built-up area west and south-west of Keighley, and such a line would be very prominent in the Cullingworth area and between Cross Hills, Cowling and Colne. They thought the deviations suggested by Dr. Forsyth and Mr. Marshall-Holmes (7) to the south of the red route would have many of the disadvantages of the blue route, and could not recommend the proposal of the Ramblers' Association (8) to route the green line from Bradford to the west of Halifax and Ripponden; this would be very harmful to pleasant residential areas and attractive countryside most of which was free from industry. The removal of some of the existing lines on the west and south of Halifax had been suggested by the West Riding County Council and would help to some extent, but the effect of such improvement would be local and the Inspectors doubted whether the expenditure could be justified. As regards Blackburn Corporation's plans on the east and south sides of the town, the Inspectors did not think industrial development need be seriously inhibited by the line, but they considered that it should skirt major residential areas and not pass directly over them unless there were good reasons.

The Board should consult the planning authorities again about the Corporation's deviation at Guide, but they did not recommend the deviation at Whitebirk or the deviations near Knuzden Hall asked for by the Trustees of Mrs. Jones' Marriage Settlement.

By letter dated 18th May, 1967 (9) the Minister of Power issued his decision granting consent to the southern line known as the green route with the exception of the sections between Eccleshill and Higher Stanhill Lancashire (the Guide deviation) in order to avoid land likely to be developed for housing by Blackburn Corporation, and between Rishworth and Barkisland West Riding of Yorkshire (Ripponden deviation) in order to avoid interference with the operations of the Halifax Gliding Club. He asked the Board to investigate alternative routes for these sections.

7.5 The Guide Deviation

At the inquiry Blackburn County Borough Council said that they accepted the need for the line but objected to its detailed siting east of the Whitebirk Power Station and in the locality of Guide. The former Local Government Boundary Commission's draft proposal for Blackburn County Borough had been that the County Borough's boundary at Whitebirk should be extended to provide for a proposed industrial area immediately to the east of the present Borough boundary. The land was, however, unallocated in the Lancashire County Development Plan and the Boundary Commission's proposals were now held in abeyance. The 400 kV line would cross the proposed industrial area for a distance of approximately two-thirds of a mile in order to get close to Whitebirk Power Station where the Board expected to have a future connection to a substation.

The Borough Council were of the opinion that the line would seriously interfere with the proper development of the area for industrial purposes. Potential developers would prefer not to have the line over their land as it would restrict the manner in which they could develop their sites and result in some sterilisation of the land. They believed that the line would detrimentally affect industrial processes involving the use of certain types of electronic equipment if it passed over or close to these. As the land was being ear-marked for the relocation of existing badly sited industries within the town they said it could result in local industries leaving the town in order to obtain industrial sites elsewhere which had not the disadvantage of being crossed by a 400 kV line. They asked that the line should be routed clear of the area suggested for inclusion within the County Borough, and if the connection to the existing Whitebirk Generating Station was later required then so far as this was practicable it should be made over the Board's own land thereby sterilising as little as possible of the land which the Council considered would be required for the relocation of existing industries. The Borough Council also desired that the line should be routed clear of other areas in the vicinity of Guide which were under discussion with the County Council for housing, re-location of industry and smallholdings. The line proposed by the Borough Council would be about 600 yards shorter and would result in no increased loss to the amenities of that locality. They considered that it was most undesirable that lines of that voltage should be routed over land likely to be required in the future for urban development, because some of the land would be sterilised, thereby increasing the cost of development and prejudicing its proper layout.

The balance of inconvenience was considered to be against the Corporation's interests and the Minister was asked that these relatively trivial concessions should be made.

It seems that the Minister was persuaded by these arguments, and in his decision did not approve this section of the proposed line, but asked that alternatives should be investigated.

The Board had discussions with Blackburn County Borough Council and Blackburn Rural District Council and proposed an alternative route that fully met their objections, which they subsequently approved. Regulations required the proposed line to be advertised, (10) and two objections were received from local residents. In both instances the objectors would see the line and towers from their houses but in neither case would the line or towers be on or over their land. The Minister apparently did not consider these objections serious enough to hold another inquiry and accordingly granted consent to this section of approximately $2\frac{3}{4}$ miles of line on 14th August, 1968.

7.6 The Ripponden Deviation

Ripponden Urban District Council appears not to have disputed the need for this 400 kV line but at the inquiry raised objection to the green route. Councillor Riley speaking for the Urban District Council said that a line on the green route would have an effect upon the everyday lives of people living in the areas through which it passed. It would be preferable to route the line through relatively uninhabited areas visited by a considerable number of people for a short time, rather than through or close to residential areas occupied by a great many people for most of their working lives, where it would be seen every day.

A petition containing 484 signatures of mostly Rishworth residents had been received by the Council objecting to the green route.

Councillor Riley said that those objecting to the red and blue routes had placed too great an emphasis on the recreational and amenity value of the areas through which the lines would pass. It also seemed to him that those supporting the green route did so largely because they considered the locality of that route to be less pretty and to some extent spoilt by existing features including traffic. The issue, he argued, should be settled on the basis of the opinions counted by heads of those actually adversely affected by the three proposals. If that was done, then either the red or the blue line would be selected; the blue route being the more logical choice. He drew special attention to the objections of the governors of Rishworth School, and the Council also supported objections from Heathfield Preparatory School, Rishworth; St. John's School, Rishworth; St. John's Church Council, Rishworth; St. John's Mothers' Union; Rishworth Women's Institute; Sowerby Division of the Girl Guides' Association; Ripponden Parochial Church Council; Ryburn Business and Professional Club; Messrs. G.H. Binns, G.W. Anderson, and E.L. Hurst, three residents of Rishworth.

From cross examination of Councillor Riley it appeared that Ripponden Council were opposed to the green route on principle and no amendment in detail would render it any more acceptable to them. The line would cross Blackstone Edge Moor which had already been disfigured by the Monk Fryston to Rochdale 275/400 kV line, and would descend to the south side of Rishworth Village across farmland, crossing the Oldham - Halifax A672 Road, close to Rishworth School, its grounds and playing fields.

Councillor Riley emphasised that the line would be very harmful to the village of Rishworth and the Generating Board had agreed that this would be so. He went on to say that from Rishworth the line would climb steeply through further farmland on the east side of the valley to cross Ringstone Edge Moor, where it would constitute a hazard to gliders taking off and landing at the airfield. The hazard would be such that if the route was approved without amendment the club would have no alternative but to cease its flying activitites. A substantial claim would be made for compensation, particularly as the Gliding Club knew of no possible alternative site anywhere in the surrounding area.

Further to the north-east the line would cross land allocated for residential development at Barkisland in close proximity to Barkisland School.

Ripponden Council was not satisfied that it had been shown that adoption of the green route was in the national interest or for the benefit of the community enough to justify the subjugation of local objection. He knew that the Board did not like the green line for technical reasons and that it would cost considerably more because of its greater length, but to his Council the blue route was the logical one because it was the cheapest and affected the least number of people.

The Minister in his letter of decision (9) deferred his decision in respect of this section of the line between Rishworth and Barkisland and suggested an alternative route north of the green route with the intention of avoiding interference with the activities of the Halifax Gliding Club.

Investigation and discussions with officers of the West Riding County Council and Ripponden Urban District Council established that no practicable interpretation of this suggestion was acceptable to either party. The Board's officers were also of the opinion that such a route would cause considerable damage to the amenities of the area.

The Board also considered an alternative route further south than the green route, (11) which if it had been welcomed by all affected parties would have been acceptable to the Board even though they considered it inferior to the green route, and would have cost approximately £70,000 more. However, this dotted blue route did not solve the problem of the Halifax Gliding Club as it would have still to some extent obstructed the approach to their landing area, as well as raising the objection of some 500 people living in the vicinity that signed a petition opposing it.

The West Riding County Council preferred the original green route although not objecting to the proposed dotted blue route. In this situation the Board said that they did not feel justified in making an application for the dotted blue route and accordingly asked the Minister to review his decision for the green route.

In view of the objections to both proposals a public inquiry was held at Halifax in November, 1968 at which all these matters were examined. (12) The Minister has not yet given his decision.(13)

7.7 Conclusion

Although this study of a proposed route of about 30 miles for an overhead line has been dealt with in considerable detail, it shows how technical matters tend to become interwoven with amenity considerations, and how these judgements are affected by economic opinions, rather than by facts. A typical example of this was the postulated loss to the tourist trade in the Bronte country because of the visual effect of a transmission line. Similarly the Board hinted that on one route because of its altitude they may have to construct the line as two single circuit lines which would involve two lines of towers instead of the single line of double circuit towers. This statement was not explained nor cross examined, but remained in the background as a mild threat. In one sense the Board can plan an overhead line route with a certain sense of objectivity, by weighing the various costs of one route against another and forming some relative assessment of the value of landscape beauty. Having decided a route there seems to be a hardening of their attitude which one may attribute to the considerable amount of personal and preliminary engineering effort required to find a practical route. The number of alternative routes over a distance of 30 miles are almost infinite, and the amount of effort required to examine every suggestion put forward, would probably be beyond the resources of the Board available for this purpose, and in any event it is highly problematical if the end result would justify the cost.

This case study has demonstrated that the Board has a very difficult task in planning the route for an overhead line, and that whatever it does is most certain to be wrong in the opinion of those persons most directly affected by the line. The view is held by a few people, that however serious the injury to visual amenity caused by an overhead line, it will prove to be neither irreparable nor permanent. An overhead power line simply demonstrates the limits of our present technical knowledge, and it may well be that within the next 40 to 50 years the present system of generation and transmission of electricity will be obsolete, and the thousands of miniature Eiffel towers with their sagging wires disappear from the landscape.

CHAPTER SEVEN

References

1. See Chapter seven bibliography for the complete list of documents referred to.

2. The Public inquiry was held in the Victoria Hall Keighley from 28th June to 7th July, 1966 by Mr. A.T. Baldock, C.Eng., M.I.E.E., a Senior Engineering Inspector of the Ministry of Power and Mr. G.A. Simpson, M.T.P.I., Dip. T.P., A.I.L.A., a Senior Housing and Planning Inspector of the Ministry of Housing and Local Government.

3. These involved the crossing of the A6033, and the A58, the crossing of the proposed Bradford to Elland 275 kV line, close proximity to the existing Monk Fryston to Rochdale 275 kV line, and spanning the Calder Valley.

4. Council for the Preservation of Rural England 40th Annual Report 1966 page 20 and 41st Report 1967 page 14.

5. Copy of Electricity Act 1957 Section 37 enclosed as Appendix G.

6. The society was represented by Miss Susan Crabtree a schoolgirl at the High School.

7. Dr. Forsyth and Mr. Marshall-Holmes did not give evidence at the inquiry, but suggested several routes in correspondence with the Minister.

8. The Ramblers Association were represented by Mr. A.J. Roberts, and Mr. J.E.K. Wilson, Chairman of the West Riding Area of the Association.

9. Letter dated 18th May, 1967, reference EL.82/16/A355 addressed to all Local Authorities concerned and objectors.

10. Regulation made under Section 34 (2) of the Electricity Act 1957 requiring the details of the proposed route to be published in at least two newspapers circulating in the locality.

11. This route was subsequently referred to as the blue route but in order to avoid confusion with the original blue route it will be referred to, and shown on the map as the "dotted blue" route.

12. The Public inquiry was held in the Marlborough Hall Halifax from 29th October to 8th November, 1968 by Mr. R.G. Anstee an Engineering Inspector of the Ministry of Power, and Mr. D.J. Easterbrook and Inspector of the Ministry of Housing and Local Government.

13. Since writing this chapter the inspector's report ref. EL82/16/A355, dated 26th February 1969 and the Ministers' decision dated 17th July 1969 has been published. The Minister gave consent to the Board's route.

PART THREE: SUBSTATIONS

CHAPTER EIGHT

Substations

8.1 Introduction

An essential part of any transmission system are the connections called substations required at the ends of every overhead line and cable. It will be appreciated that every power station, as they are all connected to the grid system, (1) will have its associated substation. This is a physical part of the power station, within the same site boundary and would therefore logically be considered with the power station complex from the point of view of siting, land use, and amenity. This thesis is solely concerned with transmission, and therefore it is not proposed to discuss power station substations, but the 130 independent substations that interconnect the supergrid network. The complete list with map references is given in Appendix I. Appendix F also schedules the year in which these supergrid substations were commissioned. It will be observed that in 1960, seventeen substations were connected to the national grid which was more than the preceeding six, or subsequent four years. 1960 was the peak year for the 275 kV supergrid, but subsequently many of these substations were extended for 400 kV working. 1966, 67, and 68 were the three busiest years for the commissioning of 400 kV substations, and it will be readily appreciated that only a very few substations will need to be built in 1969 and 1970 to complete the supergrid system as envisaged and programmed for in 1960.

8.2 General description

Electricity substations are required for two main purposes; switching and transforming. It is necessary to switch circuits to maintain supplies, to take lines and equipment out of service for repairs and maintenance, as well as to afford protection against the effects of such events as accidents, and lightning strikes. Transforming to higher and lower voltages is required depending upon the function of the line the transformer serves. By combining both these functions on one site the interchange of lines and transformers is facilitated, but not every substation is designed for both operations. A switching station need not have transformers; but a transforming station must have the ability to connect and disconnect the transformers and if necessary to bypass them.

There are numerous electrical layouts for substations, but the common essential feature is that every circuit entering the substation should be capable of being switched to any other circuit and likewise if transformers are installed. If the substation is transforming then it will comprise two or more separate compounds for each voltage. The Generating Board operates at transmission voltages of 132 kV 275 kV and 400 kV and transforming takes place only between those voltages. The electrical conductor is carried across a substation suspended from a string of insulators fixed to concrete frames in the case of 132 and 275 kV substations, or from 70 feet high steel gantries in the case of 400 kV substations. The rows of steel gantries probably form the most visually dominant feature of these substations. In an attempt to reduce the height and obstrusiveness of these structures the Board has developed another arrangement whereby instead of the conductor being hung from a supporting structure, the conductor itself is made rigid and self supporting.

Photograph 36 of a 400 kV substation showing the 70 ft. high steel gantries required for supporting live electrical equipment, described by the Board as the Mark I design. All the Board's 400 kV substations have been built so far to this design.

Photograph 37 shows a more recent improved design of 400 kV substation when the structure itself becomes part of the electrical connection. The highest part of the substation is now 42 ft. and this Mark II design of aluminium lattice construction together with the reduced height is a considerable visual improvement over the former design.

This has been achieved by means of aluminium bridge of three tubes to form a triangular cross section. The photographs prepared by the Board illustrates the considerable visual improvement the new design achieves (2).

In other parts of the substation the conductor is fixed to the top of a stack of rigid insulators mounted on a concrete post. All the electrical equipment is arranged at sufficient height for a person to walk through a live substation in complete safety. The substation is surfaced with shingle or granite chippings and the whole area enclosed with an 8 ft. high steel security fence. The general feeling of size, and the lack of any familiar objects with which to relate size, tends to leave one with an impression that the supergrid substations are massive, inhuman, and sterile creations, and to find a site of 30 acres to be occupied by such equipment in a manner acceptable to the public presents a serious and difficult problem for the Board. Fully to appreciate these difficulties it is necessary to examine the electrical and civil requirements that prescribe the choice of a substation site.

8.3 Siting criteria

There are many factors that influence the choice of a site for a substation. Firstly there is the requirement of the national system that a substation is required for some purpose of switching or transforming, which points to a general geographical location. This is more precisely defined by the local electrical requirements, which may be further modified by the physical site conditions. These considerations are further influenced by a recognition of the existing use of a proposed site and the effects that a large engineering construction would have in a particular locality. All these facotrs will need to be examined in order to appreciate how the electrical requirement for a substation is influenced by aspects of land use and amenity.

Photograph 38. Interior view of Enderby 400 kV substation showing 70 ft. high steel gantries, and the aluminium bus bars carried on stacks of insulators mounted on concrete posts. The 8 ft. high security fence helps to give some impression of the large size of this electrical equipment.

The focus of search

The general location of a substation is initially determined by the requirements of the national pattern of generation and transmission. It may be required to reinforce an existing substation caused by an increasing electrical demand from an urban area, or be near to an existing or planned source of generation that requires a connection to the Supergrid network. The area of search may be determined by the facility to provide switching at the intersection between existing and planned high voltage routes or to be near a confluence of existing high and low voltage lines which could be diverted into the new substation with a minimum of new line construction. Not all of these requirements will apply, and their relative importance will vary according to the circumstances of any specific site.

Electrical requirements

The focus of search having been defined by the needs of the system, it is implicit that the nearer the proposed site is to the focus of search the more economic is the development of the substation, because the connections to the existing network are kept short. The cost of a 400 kV overhead line is £65,000 per mile so it maybe readily appreciated that any movement away from the optimum electrical position would incur a large cost penalty.

At a recent public enquiry it was given in evidence that to move a site from the optimum electrical position to another two and a half miles away would involve a cost penalty of £680,000. This additional cost was virtually entirely due to the extent of the secondary connections to the substation, and reflected the sensitivity of such movement. To move to another suggested site six miles away would have involved an additional cost of £2,300,00. (3)

A substation site should be large enough to permit both the initial and any future anticipated development of the substation, on the basis of the most economic form of outdoor construction. If insufficient land is available increased costs may occur by the necessity of having to build a more compact enclosed substation, or by preventing future extensions. This may result in the need to find another substation site in the same general area at some later date with the consequent additional cost of interconnections.

The choice of site should permit the higher voltage lines to be taken directly into the switching station, thus avoiding the cost of cabled entries at these higher voltages. For this reason, the Board usually includes a strip of land outside the main site works fence as a "tower reserve". Once the towers have been erected in this reserve, the land between the towers and the substation can generally be made available for tree screening or agricultural purposes.

If a substation is to be connected into an existing line it is usually sited immediately alongside, so that the turning in of the line may be easily accomplished. A site directly beneath existing high voltage lines would require the line to be temporarily diverted to permit the construction of the substation, which would involve extra costs that the Board would obviously prefer to avoid. In the case where two lines cross, the preferred site would be in one of the quadrants near to the intersection, to enable the substation to be built without interruption to the operation of the existing circuits. These can then be simply and quickly connected to the substation at minimum cost.

In areas liable to heavy industrial pollution or sea spray, there is a danger of electrical flash-over due to contamination of the insulators. Where this type of environment cannot be avoided an indoor substation is usually built, involving additional construction costs. (4)

Map 35 showing location of Whitson 275 kV switchhouse in an exposed situation at the mouth of the River Severn.

Photograph 39. Whitson 275 kV switchhouse was the first switchhouse of this size, and is typical in size and appearance to many others built in exposed situations or on restricted sites.

Civil requirements

If the site is not large enough to accommodate all the electrical equipment in the standard form of layout, special designs and arrangements may be required which would involve increased civil costs. The electrical equipment is best suited for a level site but may be modified to suit gradients up to 1 in 80 in one direction only. A site on steeply sloping or undulating ground would require considerable earth moving. A rather extreme example occurred at Wymondley in Hertfordshire where it became necessary to move over 600,000 cubic yards of material to obtain the necessary minimum slope. (5) Civil costs are greatly increased if an equal cut and fill operation is not possible, and material has to be brought into, or taken from the site to achieve the required formation level.

Substations have been built on practically every type of soil from rock to bog, land liable to subsidence, and flooded disused clay and gravel pits. The civil engineer would prefer to avoid sites with such poor ground conditions because of the extra cost in constructing special foundations to carry very heavy loads, particularly those carrying transformers which can weigh up to 300 tons.

A substation must be free from the possibility of flooding so far as possible; as flooding would jeopardize the electrical supply to a large area at a time when electricity would be particularly necessary to run essential services. If however there is the remotest possibility of flooding the Board is always prepared to incur the extra cost of raising the level of the substation by filling the whole of the site. To raise a 30 acre site by six feet could easily cost anything between £75,000 and £200,000 depending upon the availability of suitable fill material. (6)

Access to a substation is required from an existing classified road to permit the passage of heavy indivisable transformer loads of up to 250 tons. The access will need to be not less than 18' 6" wide and with a height clearance of 18' 9". These are rather stringent requirements, and the selection of possible sites is sometimes influenced by the Board's desire to eliminate the costs of strengthening bridges, widening roads, easing corners, and the minimum length of new road required to the site. (7)

Consideration of ownership

The Board has on its staff, land surveyors and valuers to negotiate the purchase of land, and therefore readily recognise the effect that the acquisition of 40 acres or so may have on the operation of a farming unit. The Board endeavours so far as possible to buy land in one ownership, instead of affecting several ownerships, and particularly an agricultural unit where the loss of the acreage the Board required would not affect the viability of the farm. If the loss of acreage means that the remaining acreage is no longer a commercial proposition, then the Board is usually prepared to purchase the whole holding, and resell the land surplus to its requirements to adjoining landowners. The Board says that it tries to adopt a constructive attitude to the selection of a substation site that will affect the least number of people to the minimum degree. It is recognised that the cost of land purchase and compensation is small in comparison to the costs likely to be incurred by any alteration from the optimum electrical and civil requirements.

The Board however is reluctant to acquire land compulsorily, (8) and there is a temptation for a substation site to be determined because there is a willing vendor with an adequate area of land. This is most likely to occur in an area of protected land, designated a Green Belt or Outstanding Natural Beauty, when the existing value of the land is agricultural

The landowner knows that the planning authority would not permit any other form of development and a substation would enhance the land value only in the case of a sale to the Board. It is thought that there have been several instances where the Board have incurred increased costs for the development of a substation, by not going to the optimum electrical position because of acquisition difficulties, or by purchasing from a willing vendor at a more expensive alternative.

Amenity considerations

The Board is statutorily obliged to take in account the effect that its operations have on amenity, (9) but is also concerned because the Local Planning Authority from whom planning permission is required will be particularly aware of this aspect. It is therefore in the Board's interest to consider the affect a proposed substation will have on amenity from the very outset. A substation presents a visual impression of industrialisation, and of all the forms of land use an industrial area would seem to be the most appropriate. The Board therefore tends to choose, and is often encouraged to select a site in an area of existing or planned industrial development, or where it would be visually compatible with its surroundings. There are however certain town planning difficulties resulting from this presumption which will be discussed later in this chapter.

The general consensus of opinion seems to be that the best site for a substation from a visual amenity point of view is one that affords the maximum screening. The public does not regard a substation as contributing anything to the visual scene, and consequently such constructions are best hidden. Sites that avoid the substation structures appearing on the skyline, and those that take advantage of the natural land contours, are preferred. Conversely the Board tries to avoid sites that may be overlooked from points of public access, or those close to residential areas.

In rural areas sites that take advantage of existing tree plantations, hedgerows, and woodlands to provide immediate and effective screening tend to be favoured. A particularly successful example of this is the substation at Ninfield in Sussex which is situated at the head of a shallow valley, and is well screened by the surrouding woodlands. In this instance hardly any tree lopping or felling was required for the line entries as they were routed carefully through the gaps between the woods to the north and north west of the substation. However, when such tree screening is not present the Board usually offers, and is requested to carry out screen planting. The extent of this work is considered in a later chapter.

Occasionally a primary substation is established adjoining a lower voltage substation, because of the considerable economic and electrical advantages to be gained, but which often results in some amenity detriment. An existing substation represents a considerable investment and if a new substation is required the advantages of easy connection between them and the advantages of utilizing the existing overhead lines are obvious. Sundon substation situated adjoining the west side of the M.1. about $5\frac{1}{2}$ miles north of Dunstable is a typical example. In the beginning and a long time before the motorway was built a small 33 kV substation was established requiring about a third of an acre of land. A 66 kV substation soon followed, which was further extended to 132 kV. In about 1963 a temporary 275 kV substation was commissioned. This large extended substation is readily visible throughout its whole length from the motorway, and is tacitly recognised by the Board as constituting one of its worst affronts to visual amenity. The earliest substations at 33 and 66 kV were quite well sited and even the 132 kV development before the advent of the motorway was probably fairly acceptable. The establishment of the low voltage substation made the location of the supergrid substations almost inevitable. The air photograph clearly shows

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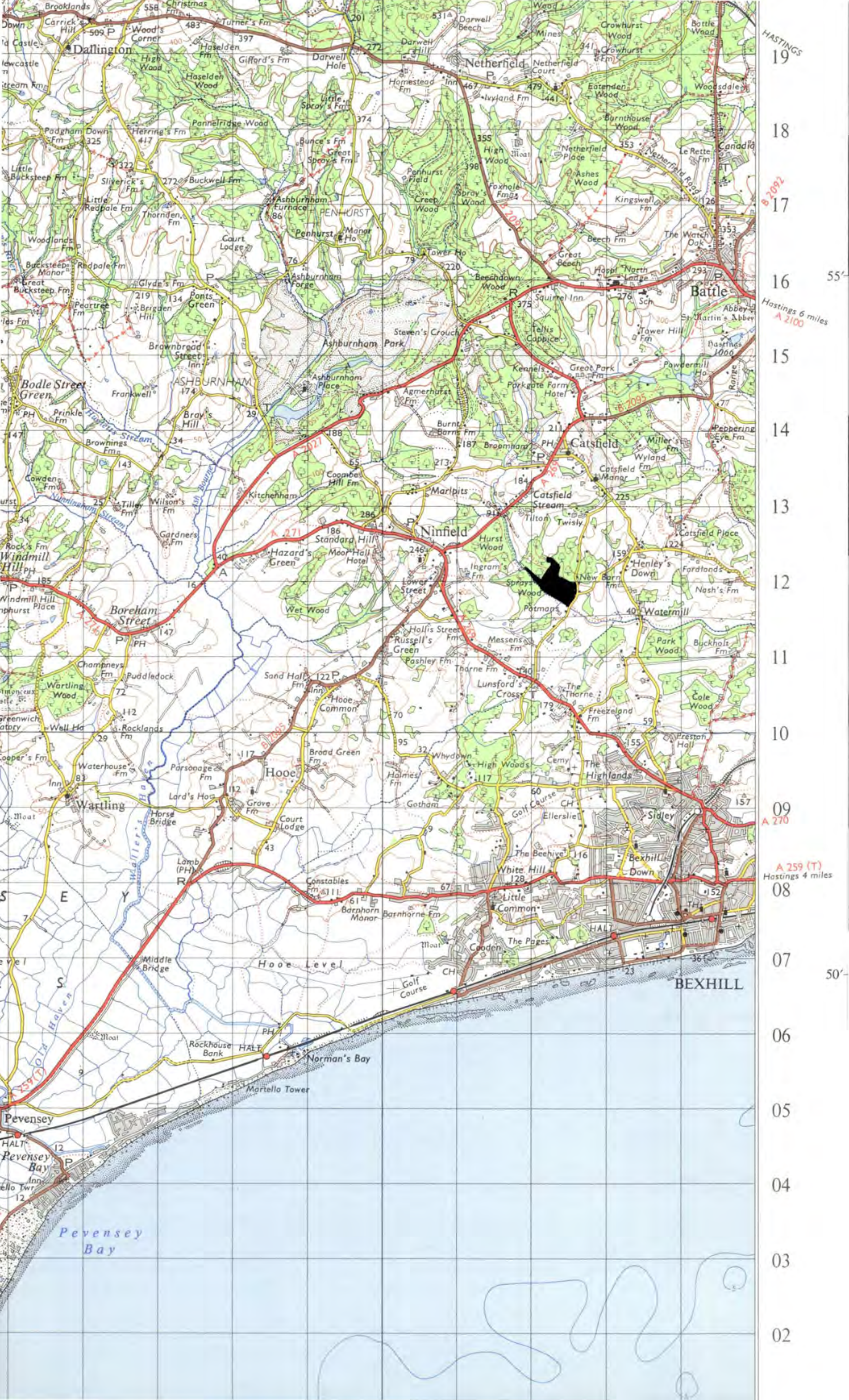
Map 36. Showing the location of Ninfield substation in East Sussex.



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Turner's Fm
Dallington
Haselden Fm
Gifford's Fm
Darwell Hole
Darwell Hill
Darwell Beech
Netherfield
Netherfield Court
Crowhurst Wood
Battle Wood
HASTINGS
High Wood
Haselden Wood
Homestead Fm
Ivyland Fm
Eatenden Wood
Woodsdale
Little Spray's Fm
Pannelridge Wood
Padgham Down Fm
Herring's Fm
Bunce's Fm
Great Spray's Fm
High Wood
Burnthouse Wood
Netherfield Place
Le Rette Fm
Canadia
Little Bucksteep Fm
Sliverick's Fm
Buckwell Fm
Penhurst Field
Foxhole Fm
Ashes Wood
Netherfield Road
Little Redpale Fm
Ashburnham Furnace
PENHURST
Creep Wood
Spray's Wood
Kingswell Fm
B 2092
Thornden Fm
Penhurst
Manor Ho
B 2096
The Watch Oak
Woodlands Fm
Court Lodge
Tower Ho
Beech Fm
Great Beech
Bucksteep Manor
Redpale Fm
Ashburnham Forge
Beechdown Wood
Hospl
North Lodge
Battle
Great Bucksteep Fm
Glyde's Fm
Ponts Green
Squirrel Inn
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Abbey
St Martin's Abbey
Hastings 6 miles
A 2100
Peartree Fm
Brigden Hill
Steven's Crouch
Tellis Coppice
Tower Hill Fm
Ashburnham Park
Battle 1066
Brownbread Street
Inn
Kennels
Great Park Fm
Powdermill Ho
Bodle Street Green
Frankwell
ASHBURNHAM
Ashburnham Place
Agmerhurst Fm
Parkgate Farm Hotel
B 2095
Prinkle Fm
Hugletts Stream
Bray's Hill
Burnt Barns Fm
Peppering Eye Fm
Brownings Fm
A 2027
Broomham
Catsfield
Miller's Fm
Wyland Fm
Cowden Fm
Coombe Hill Fm
Marlpits
Catsfield Manor
Tilley Fm
Wilson's Fm
Kitchenham
Catsfield Stream
Tilton
Twisly
Ninfield Stream
Ash Bourne
Gardners Fm
A 271
Standard Hill
Ninfield
Hurst Wood
Catsfield Place
Rock's Fm
Windmill Hill
Hazard's Green
Moor Hall Hotel
Ingram's Fm
New Barn Fm
Henley's Down
Fordlands
Lower Street
Spray's Wood
Nash's Fm
Windmill Hill Place
Boreham Street
Wet Wood
Potmans
Watermill
A 269
Hollis Street Fm
Messens Fm
Park Wood
Buckholt Fm
Russell's Green
Pashley Fm
Champneys Fm
Puddledock
Thorne Fm
Sand Hall Fm
Hooe Common
Lunsford's Cross
The Thorne
Cole Wood
Wartling Wood
Freezeland Fm
Rocklands
Well Ho
Preston Hall
B 2095
Broad Green Fm
Whydown
High Woods
Cemy
The Highlands
Cooper's Fm
Waterhouse Fm
Parsonage Fm
Hooe
Holmes Fm
Inn
Wartling
Lord's Ho
Horse Bridge
Grove Fm
Gotham
Golf Course
Ellerslie
Sidley
Moat
Court Lodge
A 270
Lamb (PH)
Wallers Haven
The Beehive
Bexhill Down
White Hill
A 259 (T)
Hastings 4 miles
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Constables Fm
Little Common
Barnhorn Manor
Barnhorne Fm
HALT
Moat
Cooden
The Pages
Middle Bridge
Hooe Level
Golf Course
BEXHILL
Rockhouse Bank
HALT
Norman's Bay
Old Haven
Martello Tower
A 259 (T)
Pevensey
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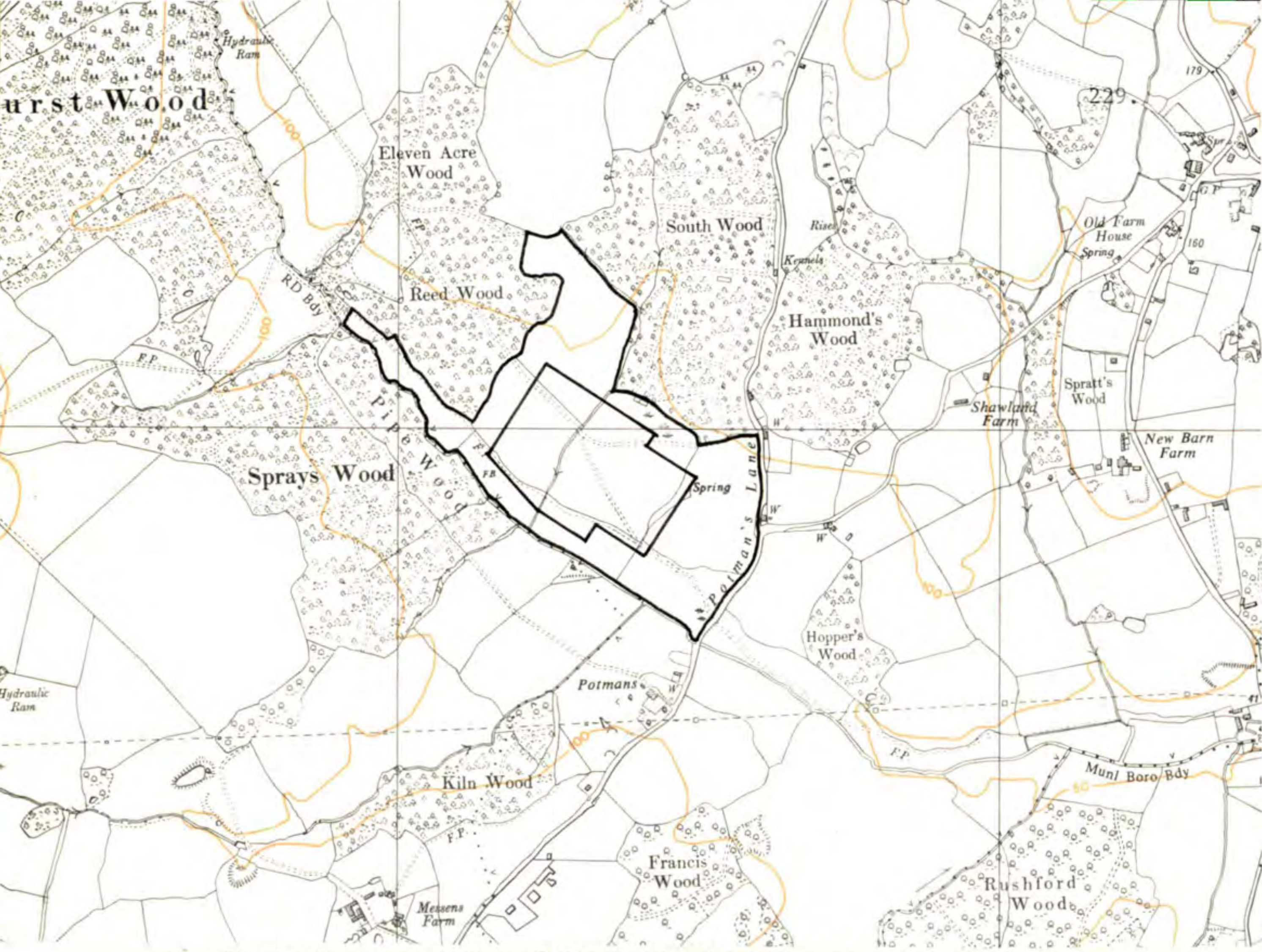
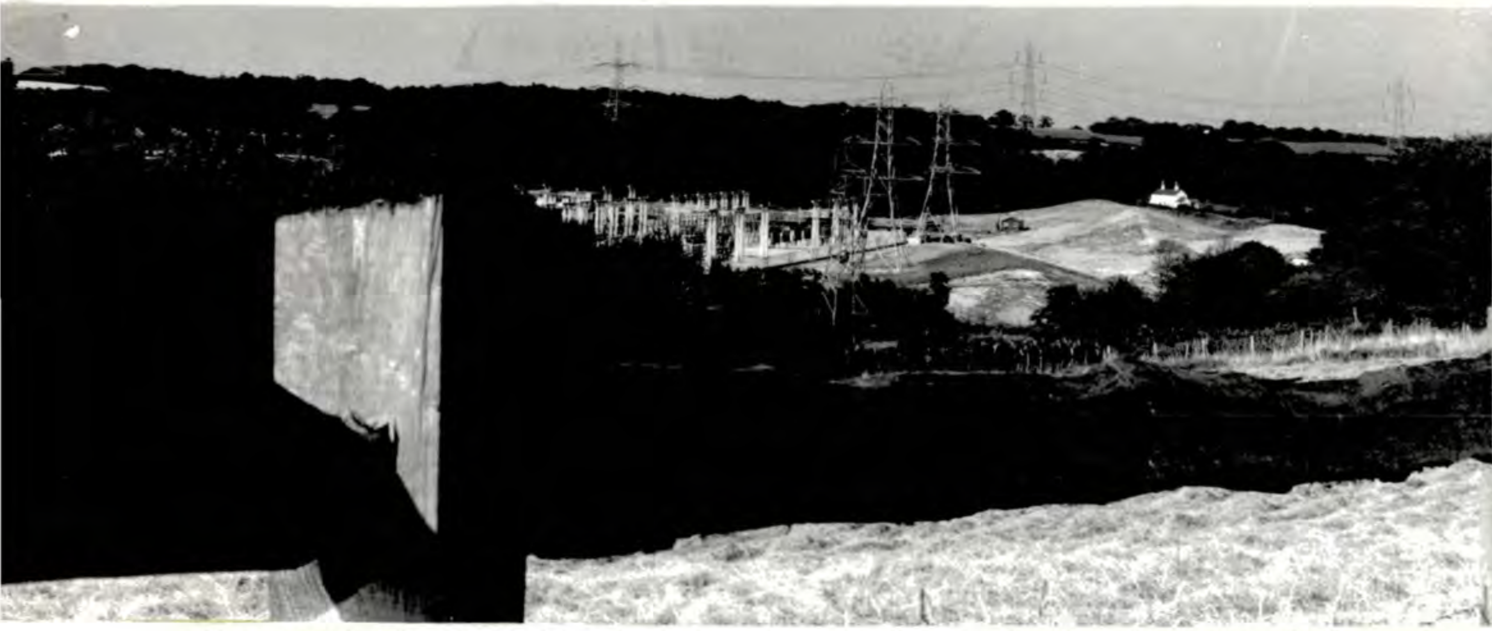
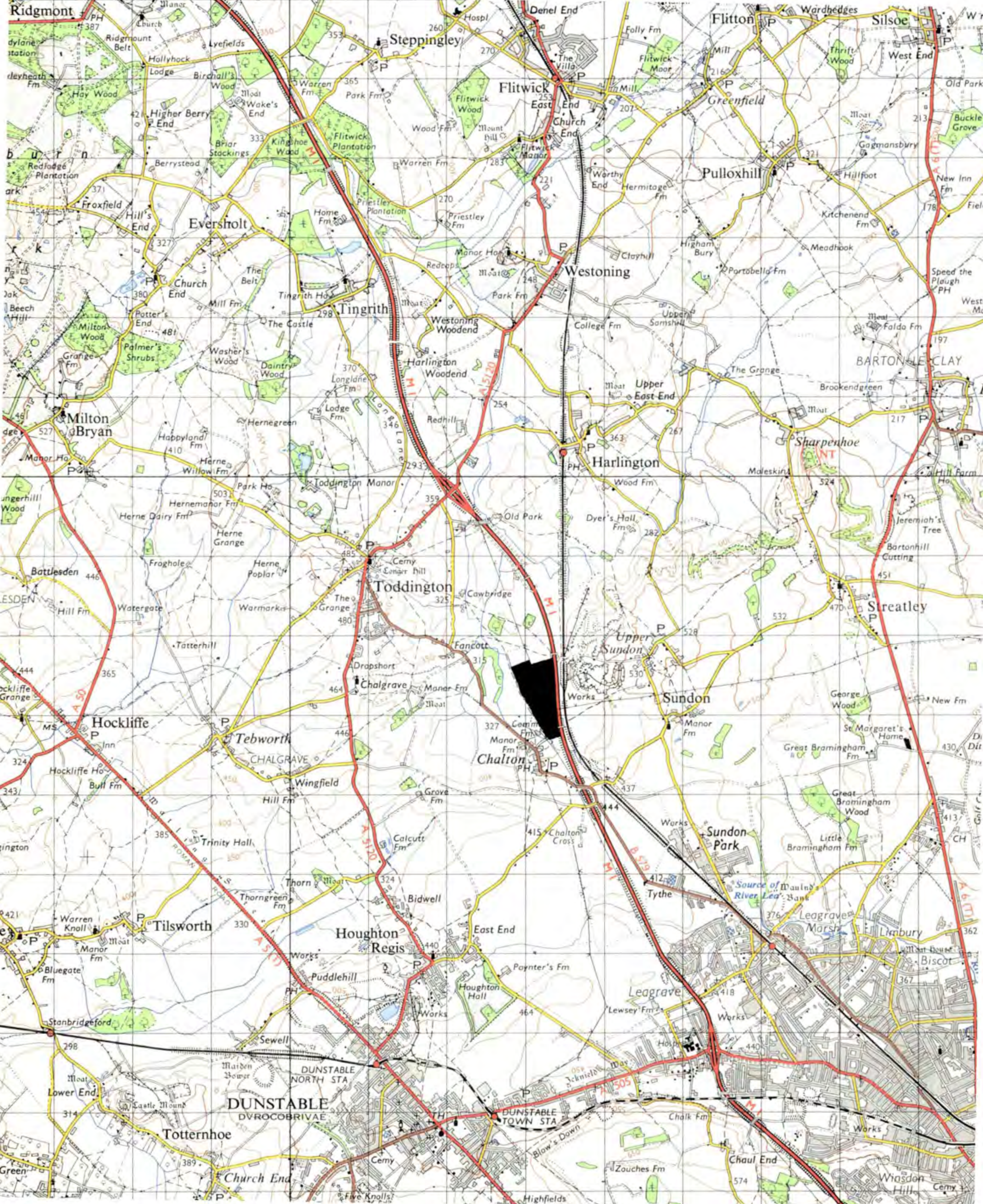


Map 37 showing the siting of Ninfield substation enclosed on three sides by woods, and positioned on the side of a shallow valley.



Photograph 40. Ninfield substation is regarded by the Board as one of the best examples of good siting from an amenity point of view. The substation structures that were coloured grey are barely distinguishable in the top left of the photograph.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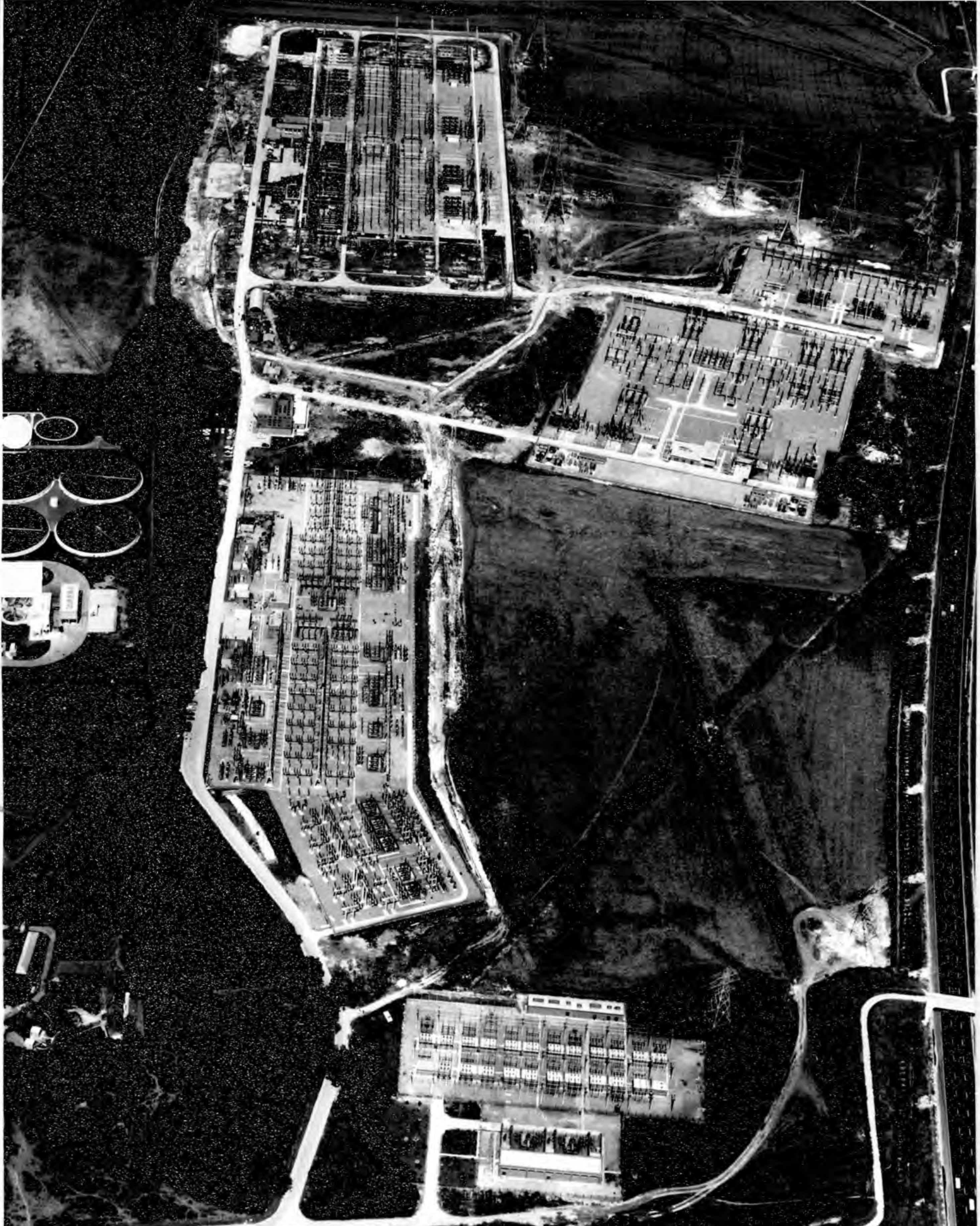
Steppingley
Denel End
Flitton
Wardhedges
Silsoe
West End
Flitwick
Greenfield
Higher Berry End
Wake's End
Flitwick Plantation
Flitwick Wood
Flitwick Manor
Buckle Grove
Gagmansbury
Pulloxhill
Hillfoot
New Inn Fm
Redfodge Plantation
Berrystead
Froxfield
Hill's End
Eversholt
Church End
Priestley Plantation
Priestley Fm
Manor Ho
Westoning
Clayhill
Higham Bury
Meadhook
Kitchenend Fm
Portobello Fm
Tingrith
The Castle
Milton Wood
Palmer's Shrubs
Westoning Woodend
College Fm
Upper Samshill
Faldo Fm
BARTON-LE-CLAY
The Grange
Brookendgreen
Harlington Woodend
Upper East End
Sharpenhoe
Milton Bryan
Hernegreen
Lodge Fm
Redhill
Harlington
Manor Ho
Toddington Manor
Wood Fm
Moleskin
Hill Farm
Herne Dairy Fm
Hernemanor Fm
Old Park
Dyer's Hall Fm
Jeremiah's Tree
Bartonhill Cutting
Battlesden
Froghole
Herne Grange
Herne Poplar
Toddington
Cawbridge
Streatley
Hill Fm
Watergate
Warmark
The Grange
Tatterhill
Fancott
Upper Sundon
Dropshort
Chalgrave
Manor Fm
Works
Sundon
George Wood
New Fm
Hockliffe
Tebworth
CHALGRAVE
Manor Fm
Chalton
St Margaret's Home
Great Bramingham Fm
Hockliffe Ho
Bull Fm
Wingfield
Hill Fm
Grove Fm
Great Bramingham Wood
Trinity Hall
Chalton Cross
Sundon Park
Little Bramingham Fm
Calcutt Fm
Thorn
Thorngreen Fm
Tythe
Source of River Lea
Bidwell
Leagrave Marsh
Limbury
Tilsworth
Warren Knoll
Manor Fm
Houghton Regis
East End
Biscot
Bluegate Fm
Puddlehill
Poynter's Fm
Houghton Hall
Leagrave
Lewsey Fm
Stanbridgeford
Sewell
Maiden Bower
DUNSTABLE NORTH STA
Lower End
DUNSTABLE
DVROCOBRIVAE
Castle Mound
DUNSTABLE TOWN STA
Chalk Fm
Totternhoe
Blow's Down
Chaul End
Church End
Zouches Fm
Five Knolls
Highfields
Wisdon Hill
M1
A 5120
A 5(T)
A 50
A 6(T)
A 505
B 579

Please turn over for:-

Map 38 showing location of Sundon substation adjoining the M.I motorway from which it is very conspicuous. The motorway was built after the establishment of the substation, and demonstrated that future development should be borne in mind when proposed substation sites are being considered.



Photograph 41. Aerial view of Sundon 132/275/400 kV substation looking north. The capital invested in the original substation at the bottom of the photograph, became the justification for the siting of the subsequent larger installations.

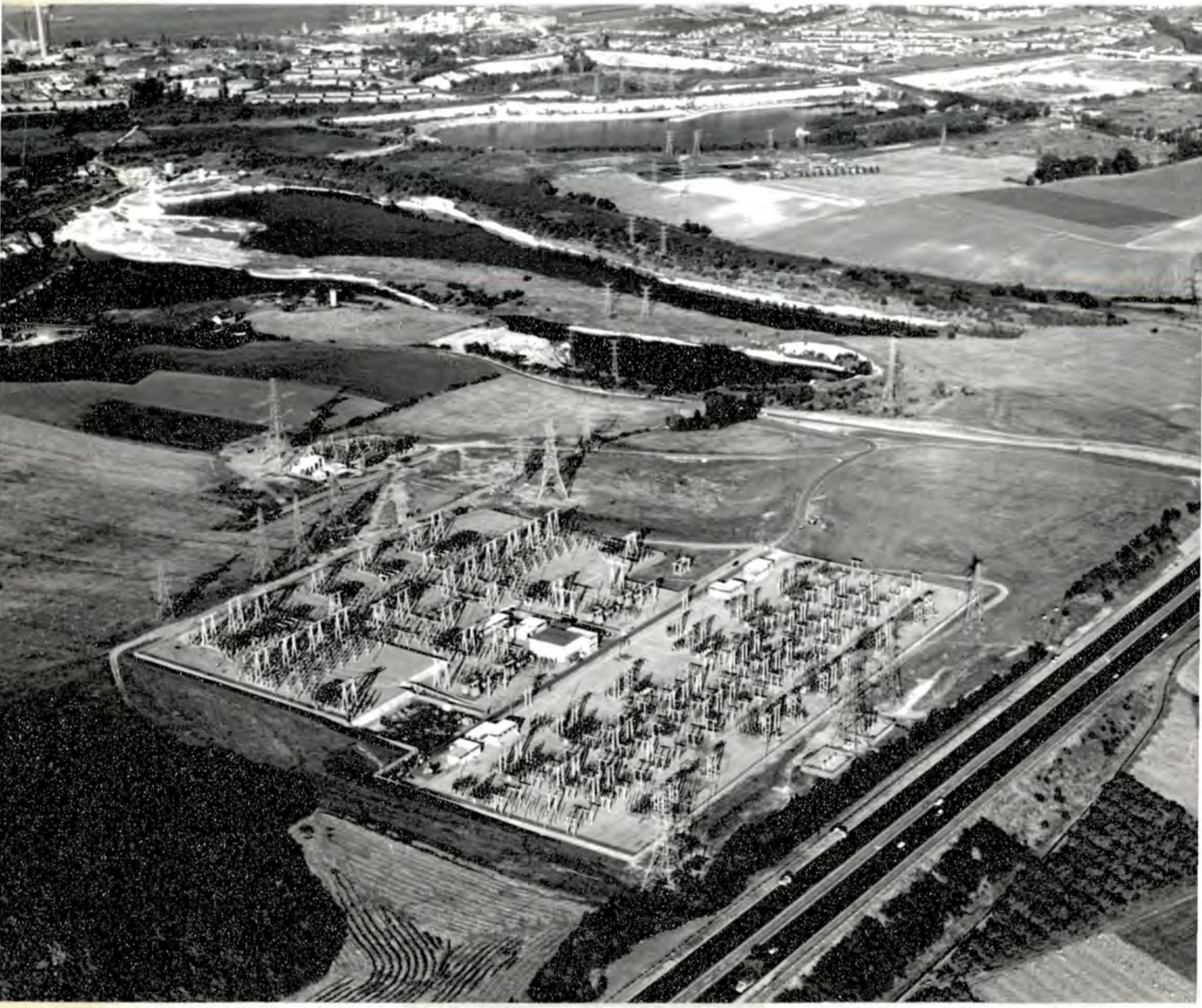
the growth of Sundon substation, which illustrates how the capital invested in a site becomes the overriding factor determing the location of large voltage substations, even though the initial capital may be small in respect to the subsequent developments. A similar situation is shown in the air photograph of Northfleet substation adjoining the A2(M).

Local Planning Authorities when asked to approve sites for proposed substations, even if well sited and screened, would be wise to view the possibility of the substation being extended or even rebuilt to a higher voltage. They should consider whether the selected site would still be acceptable under such circumstances and act accordingly. The case of Sundon which is only typical of several others (10) should be a warning to alert Planning Authorities to this possibility.

Consideration of associated overhead lines

It is generally recognised that the worst visual aspect of a substation is the concentration of overhead lines, converging on to a substation. This suggests that the Board should study the routes of all the future line entries to a proposed substation site in order to assess its likely impact on amenity. This may indicate that a substation site less favourably concealed may have an overall amenity advantage, because the visual offence of the line entries is less. Nearness to the focus of search will reduce the length of overhead line connections which in itself is a considerable amenity advantage. It will be readily appreciated that there is considerable room for differences of opinion when a fairly open substation site has the advantages of short connections with a cost saving, over an alternative site well screened, but requiring extended connections, even if such connections are not conspicuous.

Map 39 showing location of Northfleet West 275/132 kV substation adjoining the A2(M). The overhead line network to this substation and the nearby Northfleet East 132 kV substation is generally regarded by the Board as their worst example of a concentration of towers and lines.



Photograph 42. Air view of Northfleet West substation as an example of bad amenity siting. The substation being on lower ground is very conspicuous from the A2(M) and the trees on the embankment are unlikely to provide screening for many years.

Reduction of acoustic interference

A substation generates a certain degree of noise which derives mainly from the operation of transformers and circuit breakers. Transformers emit a low hum, and circuit breakers when operated make a very large crack accompanied by a deep thud. This noise is sufficient to cause an unsuspecting person nearby to jump with surprise, and alarm. These loud bangs can be very disturbing to local residents, although animals seem to become accustomed to the noise. There are however occasionally exceptions when the Board has been presented with a claim for the loss of farm animals that have aborted as a consequence of the operation of 400 kV circuit breakers. Transformers can be enclosed, and circuit breakers can be fitted with muffs, or an alternative design used that substantially reduces noise, but all these ways of ameliorating the noise nuisance represents an additional cost to the substation. Whether or not action is taken by the Board to reduce noise, there is a tendency to site a substation as far away as possible from any dwelling.

8.4 Land use

An attempt has been made to see if there is any underlying principle or policy of the Generating Board that is discernible in the selection of substation sites. A survey of all 400 kV and 275 kV switching and transformer sites in England and Wales was made to establish the former use of the substation site before construction, and the Local Planning Authorities proposal for the use of such land indicated on their Development Plans. A total of 128 substation sites were investigated (11) and the results are set out in Tables 6 and 7.

It is appreciated that it would be difficult to find a site of about 30 acres in an urban area, so that it is not surprising that the majority of substation sites are on agricultural land, which is reflected by

Former Land Use	No. of sites
Agricultural	74
Allotments	1
Derelict	14
Disused pits	5
Disused power station sites	7
Foreshore	1
Heath land	1
Industrial	4
Refuse tip	1
Residential	1
Water meadows	2
Woodlands	5

Table 6. Former land use of primary substation sites.

Development Plan Zoning	No. of sites
White land	84
Industrial	12
Area for deposit of Waste Materials	4
Sewage disposal	2
Gravel extraction	2
Clay working	1
Chalk extraction	1
Mineral workings	1
Residential	2
Public Open Space	3
Ministry of Supply Land	1
War Department Land	1
Water Works	1
Surface winning of coal	2
Land drainage - washlands	2
Statutory allotments	1
Green Belt	36
Area of Outstanding Natural Beauty	1
Lee Valley Regional Park	2

Table 7. Development Plan zoning of primary substation sites.

the Local Authority's Development Plan zoning of white land (12). Agricultural land is easy and relatively cheap to acquire and is usually fairly economical to develop. The fact that 36 of these rural sites are in Green Belts seems to have presented very little difficulty to the Board. Of the eleven primary substation sites that have been the subject of a public inquiry, (13) eight were either in a Green Belt or proposed Green Belt. The Local Authority's objection may not have been principally because the substation was sited in an area of protected land, but nevertheless in every case the Minister of Housing and Local Government allowed the appeal, and permitted the development.

One such appeal concerned a proposed substation site at Berkswell situated four and a half miles to the south west of Coventry which was refused by the Warwickshire County Council for the reason that:-

> "The proposed site, although lying within a rural area forms part of the proposed Green Belt around Coventry, is also in close proximity to residential development. It is considered that an electricity sub-station of the size proposed with the mass of large external equipment, together with the numerous and very high pylons, would be injurious to the amenities of the area and could also cause a nuisance to residents in the locality". (14)

Following a public inquiry (15) the Inspector wrote:- (16)

> "I do not believe that making an exception to green belt policy here, for a public service development of a kind that frequently has to go on green belt land, need make it difficult to refuse general development. Moreover in this particular situation it is further residential development that is most likely to need resisting, and the proximity of an electricity sub-station might well lessen that pressure". The Minister accepted this view and allowed the substation (17).

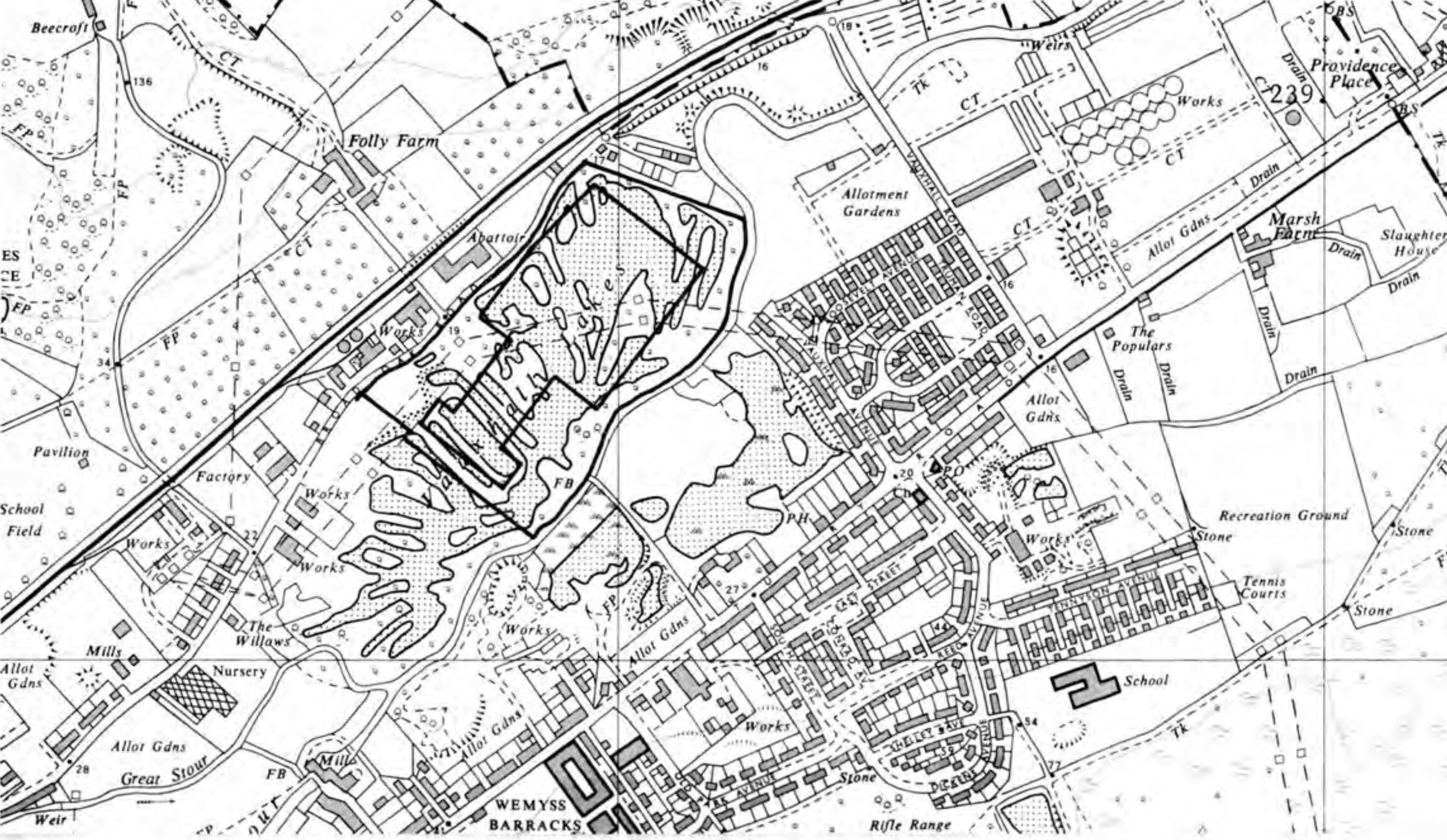
A similar case occurred when the Board proposed to build a substation site at Mop End near Amersham in Buckinghamshire. The site is situated within an Area of Great Landscape Value, and is included within the proposed extension to the Metropolitan and Local Green Belt, and is also within the Chilterns Area of Outstanding Natural Beauty.

The Local Authority objected mainly on the grounds that a substation should not be permitted in such protected areas and pressed their objection to a public inquiry. The Inspector in his report said that he came to the conclusion that the proposed substation constituted very special circumstances, and as such the development could be considered within a Green Belt or Area of Outstanding Natural Beauty (18).

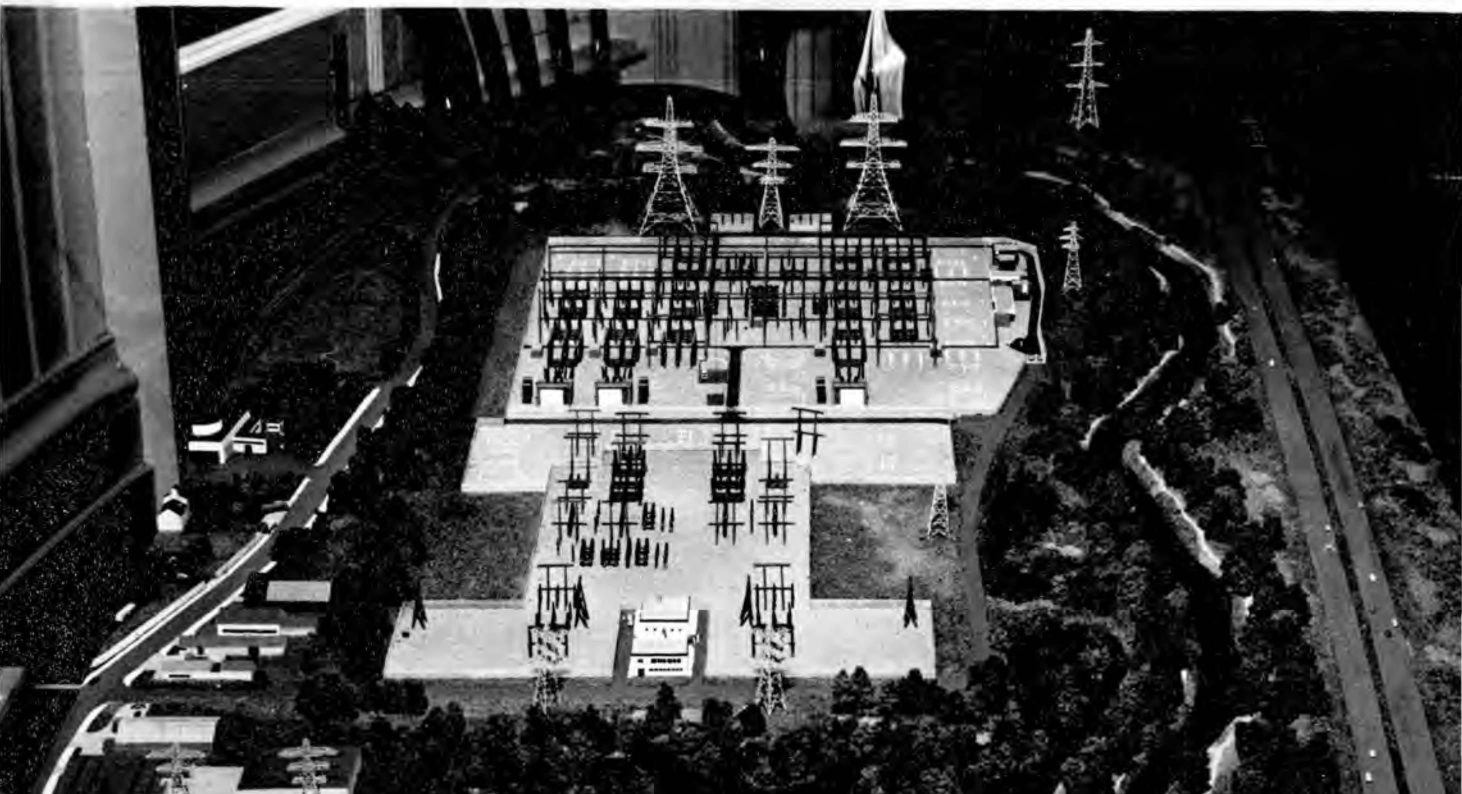
As previously mentioned one may assume that the most appropriate location to site a substation from the point of view of land use, would be in an area zoned by the Local Planning Authority for some form of industrial use. Only twelve instances of this occuring have been recorded but when it does it usually meets with universal approbation. There has been however, one instance when such a proposal was rigorously opposed by the Local Planning Authority (19). This happened in the case of Birkenhead substation when the Board had selected a disused brickworks site which had been rezoned for light industrial use. The Local Planning Authority agreed that a substation of the sort proposed would fall within the definition of light industry and conform with the proposed zoning of the site, but as there was a shortage of industrial land within the Borough the use of this land for a substation would deprive the Borough of the opportunity to relocate non conforming industrial users, whereas a substation could well be sited on the nearby agricultural land.

Following the recommendations of the Inspector in his report, (20) the Minister in his decision letter, (21) said that he was of the opinion that there were no substantive grounds for withholding permission for the development of this brickworks site for the purposes of a substation. The Birkenhead area had been carefully investigated by the Central Electricity Generating Board for possible alternatives sites and at every stage there had been full consultation with the local planning authority. The Minister was in no doubt that the appeal site was the best one available in the area for the purpose, and he said it was clear from the local planning authority's approach to the matter that their sole anxiety was that their wishes regarding the further allocation of industrial land in the borough would be endangered by the taking of this one area on which they thought they could rely, He added that the question of industrial land requirements was under consideration and that even if there were shown to be a need for further industrial land, as well as the proven need for land for a substation, then the search for suitable land for industrial purposes would have to continue. He was fully satisfied that the erection of a substation on the appeal site was an appropriate use for the land, having regard to its location in the existing grid system and its unique hiding capacity for a use which was normally so difficult to fit into the landscape. In his opinion it would be easier, should it prove necessary, to find other land more amenable to light industrial development than it would be to find a suitable alternative site for this large substation. He recommended that the appeal be allowed.

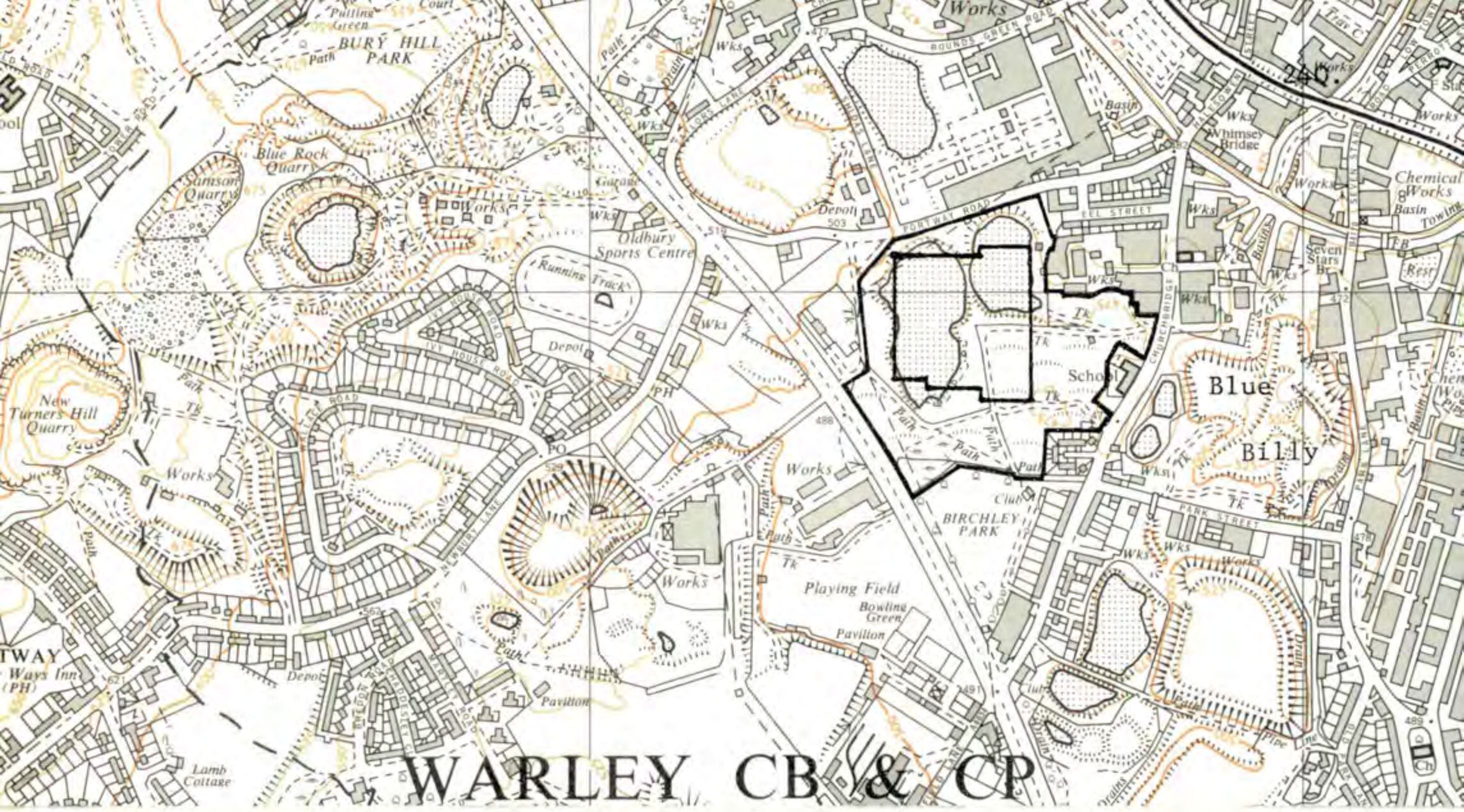
There has been a tendency for local authorities to encourage the Board to develop sites which required such difficult and expensive site works that no private developer, or the authority would consider. The considerable resources of the Board and the high capital investment in a substation site, with a readily obtained planning permission has persuaded the Board to undertake such difficult sites. Canterbury substation was built on wet gravel pits that had to be filled, Oldbury substation is sited on a former 50 foot deep flooded clay pit, and the substation at South Manchester required the removal of many thousands of cubic yards of household and industrial refuse. Table 6 shows that about 20 sites were developed by the Board that were unlikely to have been developed by anybody else. To this extent the extra costs the Board has borne to use these 'difficult' sites could be regarded as a contribution to the redevelopment of otherwise



Map 40. Location of Canterbury 400/275 kV substation on site of Vauxhall Lakes.



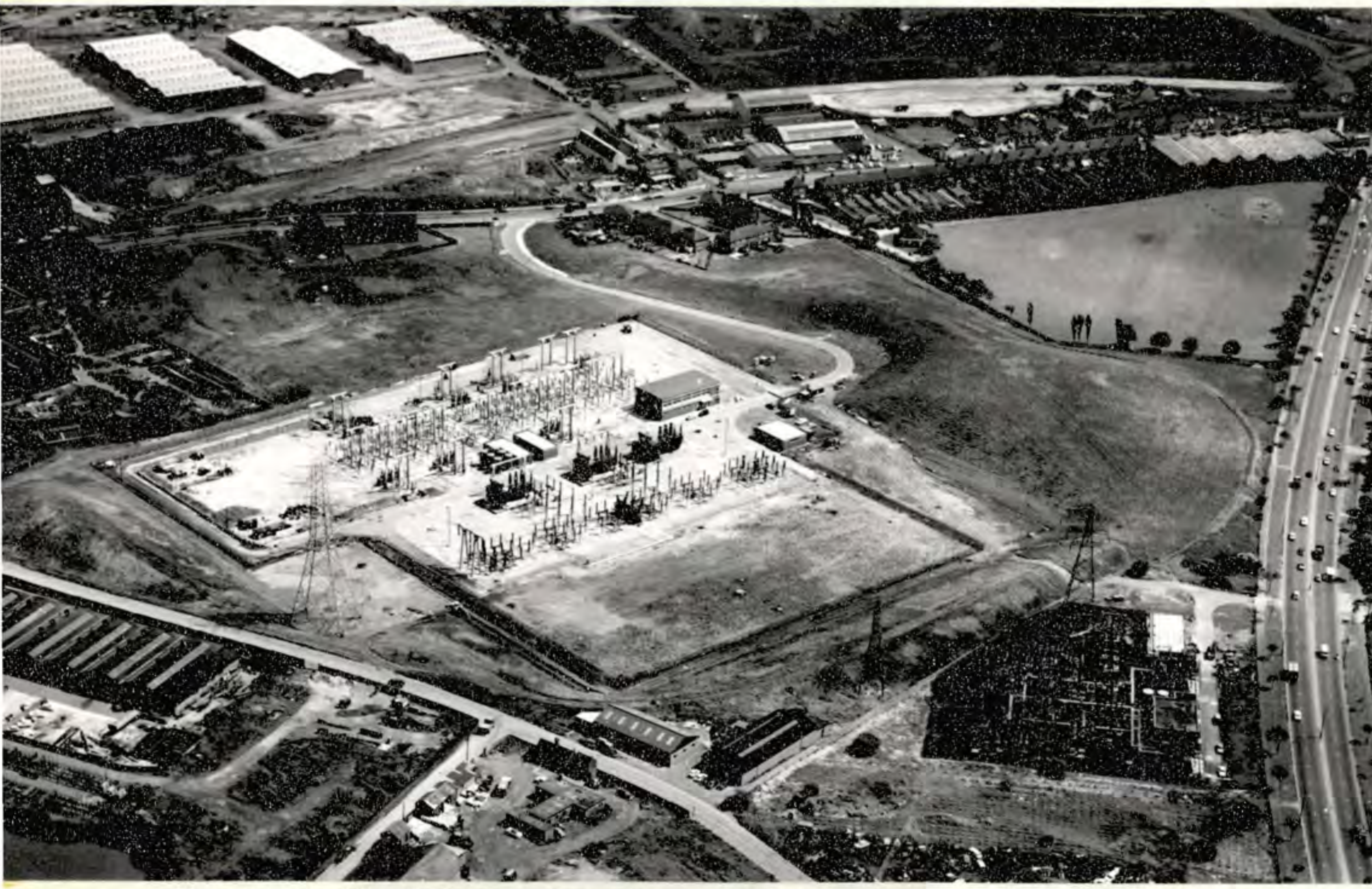
Photograph 43. Model of the proposed Canterbury substation showing the Vauxhall Lakes filled and the site landscaped.



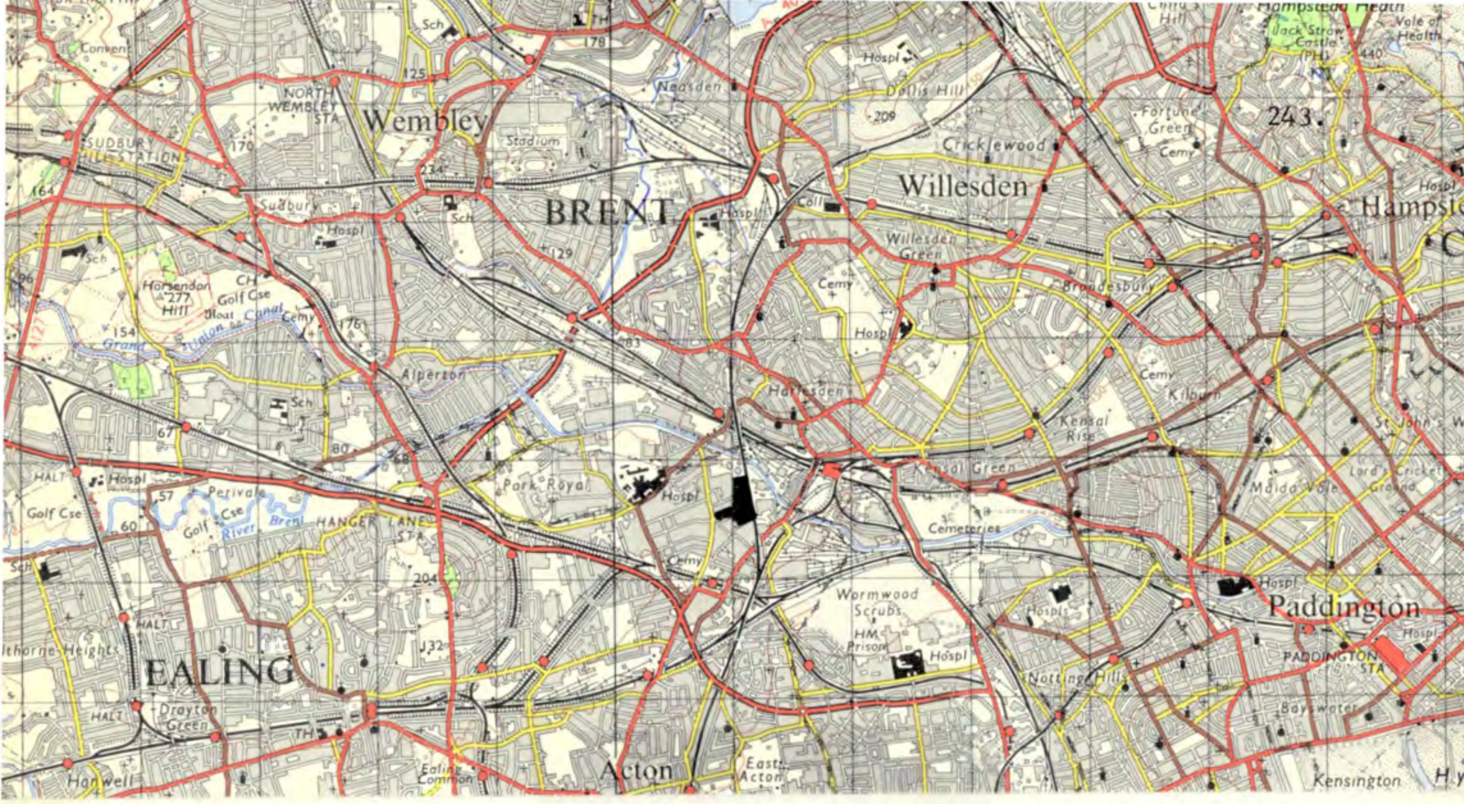
Map 41 showing location of Oldbury 275/132 kV substation on disused marl pits.

Photograph 44. View from 'Blue Billy' westwards across the proposed Oldbury substation site, showing general character of the area of industrial dereliction.

Photograph 45. Air view showing the removal of 'Blue Billy' on the right of the photograph to fill the marl pits to the left of the photograph, to form Oldbury substation site.



Photograph 46. Oldbury substation nearing completion. The extensive ground modelling and land reinstatement is particularly significant.



Map 42 showing the location of the Willesden 132 kV and 275 kV switch-houses in South London where it is very difficult for the Board to find suitable land for outdoor substations.

Photograph 47 showing 132 kV switchhouse in foreground and a 275 kV switch-house behind at Willesden. The Board justifies the cost of these buildings on the ground that this was the only way to get all the electrical equipment required on to this restricted site.

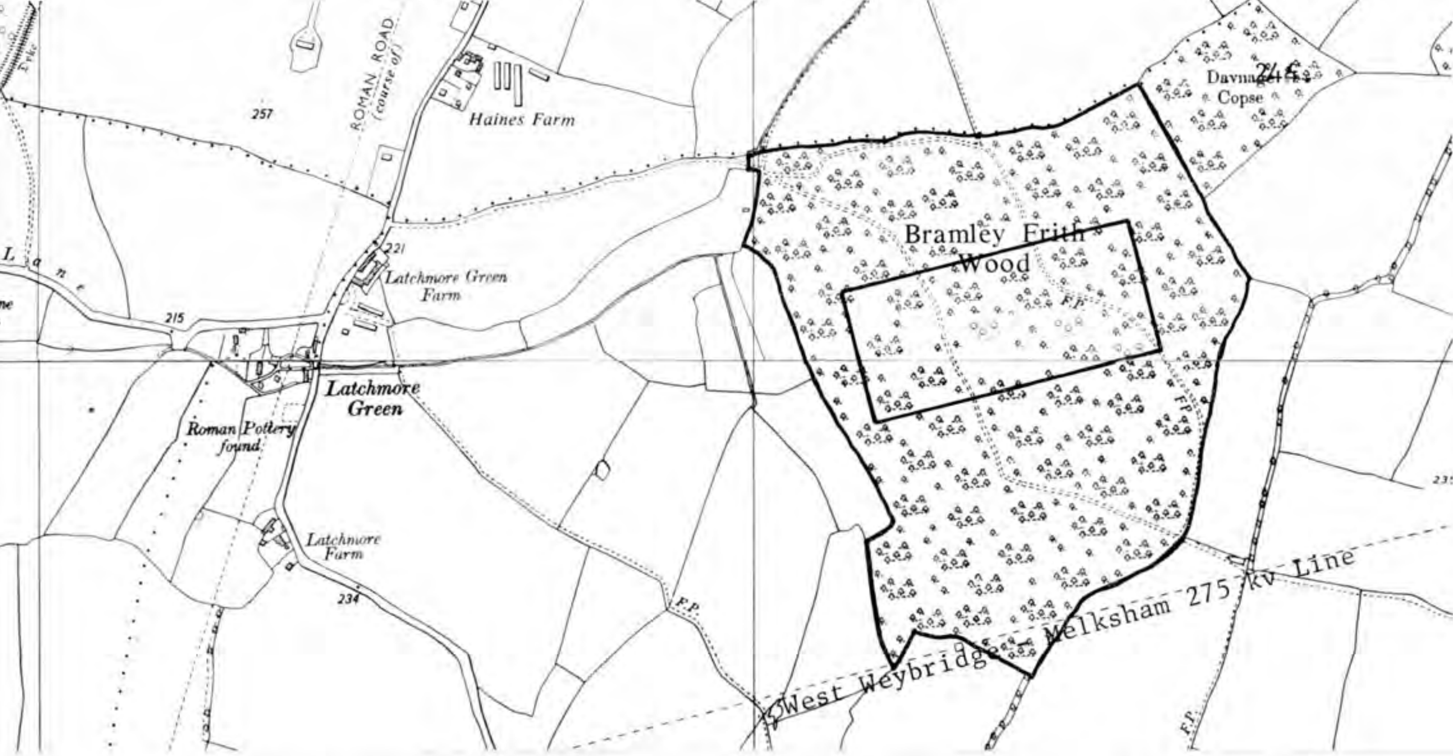
derelict areas. For instance in order to fill the 50 foot deep pit at Oldbury substation the Board almost completely removed a nearby large tip of industrial waste, and in consequence two areas of about 30 acres of industrial dereliction were reclaimed, in one case as a substation, and in the other for factories. Oldbury is perhaps the only case on record where it may be said that the construction of a substation has actually improved the visual scene.

In the Greater London area about the only land available to the Board for the construction of new substation is on land they already own, and several of the older and smaller power station sites have been redeveloped as substations. An outdoor substation requires more land for the same electrical benefit than an enclosed substation and because of the high land values in London and the limitations of site size there is a tendency to cram on to every available electrical site as much enclosed equipment as the Planning Authority will permit (22).

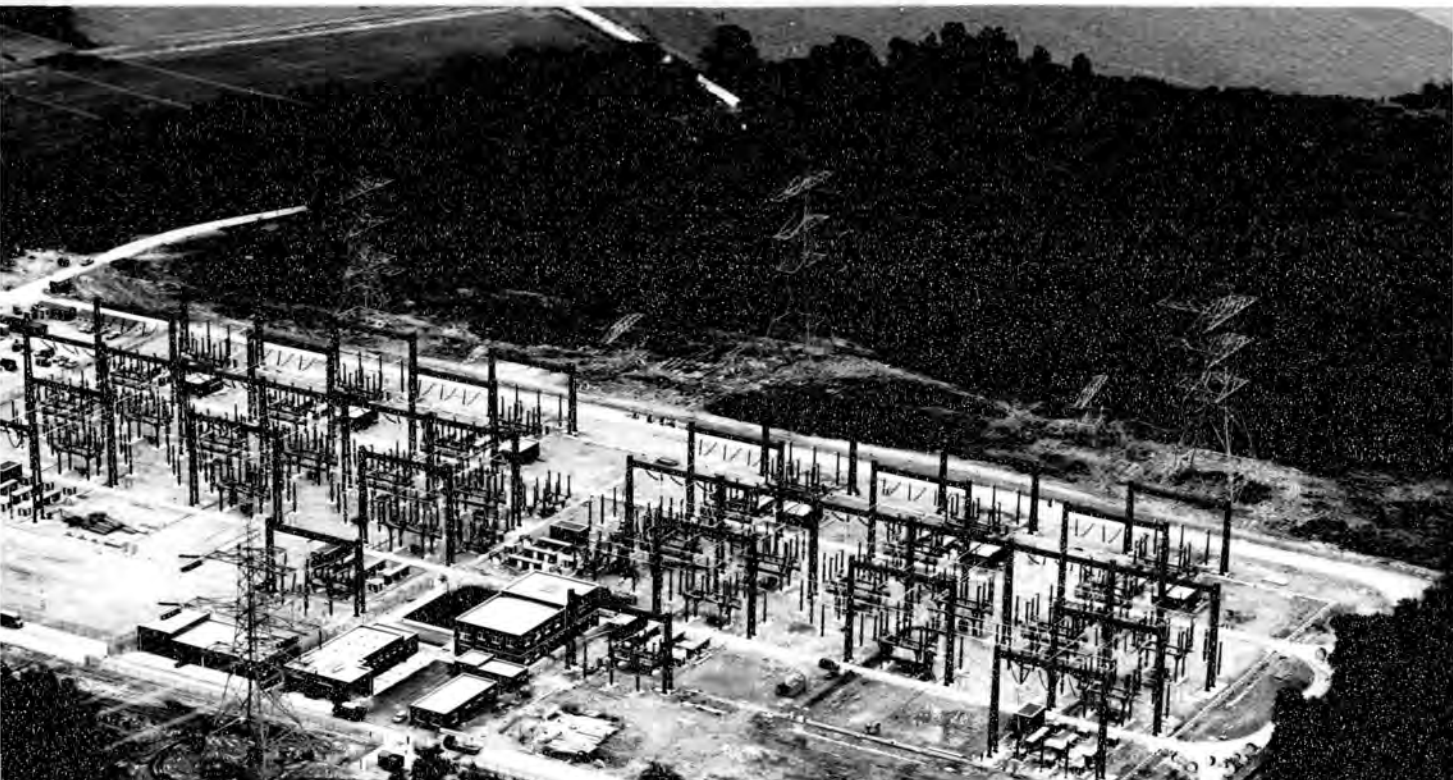
Woodlands because they afford a ready made screen to the substation tend to be favoured by the Board as a substation site and also to some degree by planning authorities. A typical example is at Bramley just north of Basingstoke in Hampshire where the whole wood of 90 acres was purchased to provide screening for the 30 acres of the substation. The Generating Board regards this as the perfect substation site. (23) Fleet substation in Hampshire has also been illustrated by the Board to suggest the ideal substation siting for perfect screening. (24) A substation has also been established in Hilcot Wood at Seven Springs, Gloucestershire, lines still have to be brought into the substation, and unless care is taken some of the advantage of woodland screening may be lost. (25)

8.5 <u>Acquisition Areas</u>

A 132 kV substation will require between 5-7 acres, a 275 kV substation 10-15 acres, and a 400 kV substation up to about 30 acres.



Map 43 showing the siting of Bramley substation in Bramley Frith Wood which provided excellent screening as well as being conveniently located for the turning in of the Melksham-West Weybridge 275 kV line.



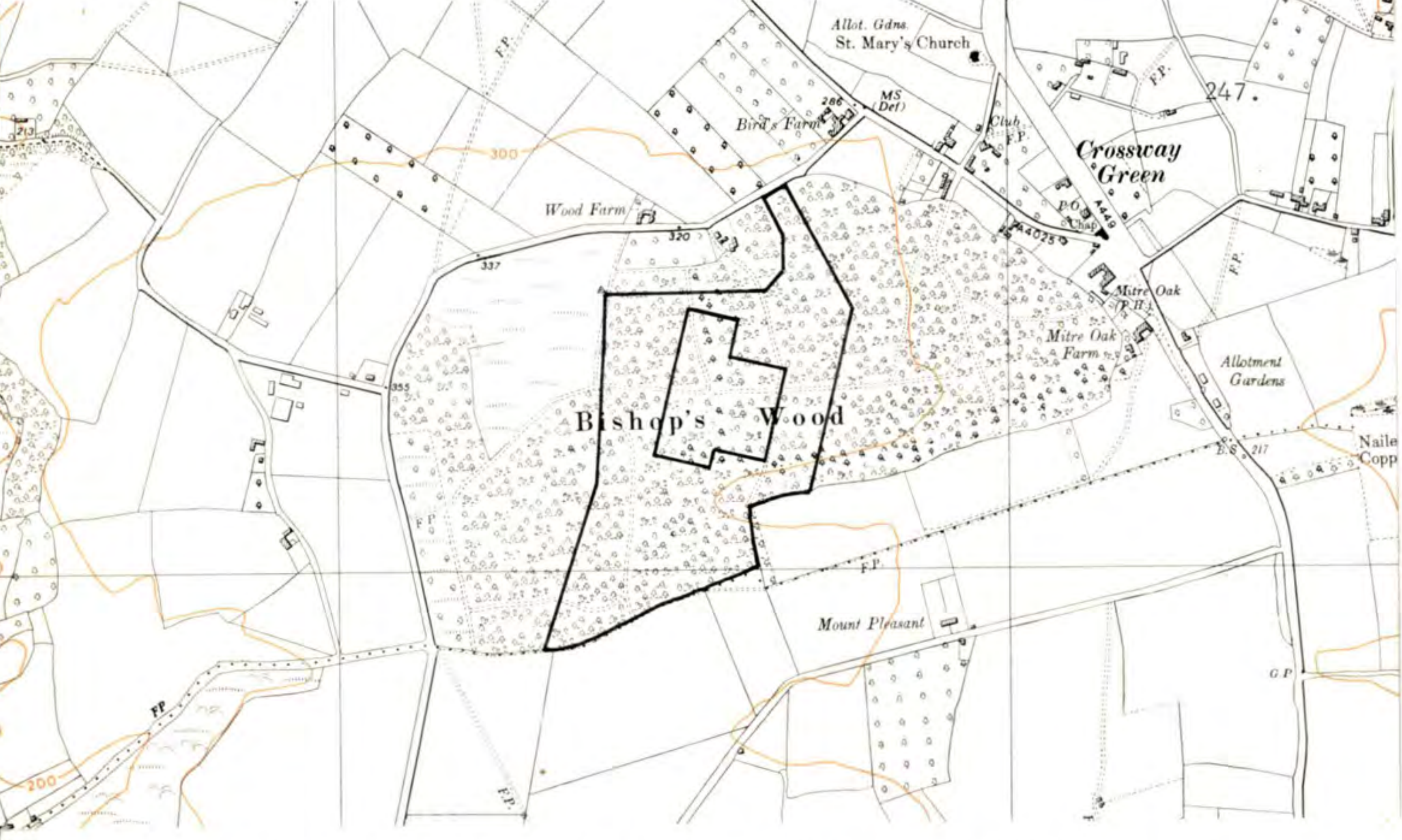
Photograph 48. South easterly aerial view of Bramley substation which illustrates the Board's concept of the ideal substation site.

Please turn over for:-

Map 44 showing the siting of the 132 kV, 275 kV and 400 kV substations in Coxmoor Wood, known as Fleet substation, Hampshire. It was considered that the siting of a substation in a wood seemed to provide the perfect solution to the problem of screening, and Fleet substation became the first of several substations similarly sited in persuance of this policy.

Gillet's Copse
School
228
Dogmersfield
Queen's Head (P H)
Pilcot Bridge
Culver's Cottage
S F I E L D
Pilcot
Dower House
Pilcot Mill (Disused)
215
238
245
Tundry Hill
All Saints Church
Rec
undry Pond
229
Parsonage Copse
Blacksmith's Bridge
Peatmoor Copse
Hill House
Brook Hill
226
Brook House
a r k
CROOKHAM
Old Parsonage
Ormersfield Farm
Stroud Lane
Double Bridge
FP
Whitlow Alders
235
Chequers (P H)
Lodge
P A R K
Bridge House
Wharf
Chequers Bridge
Cunningham's Row
256
All Saints Church (Disused)
286
255
Swing Bridge Copse
263
Floods Farm
Post
Stones
Stone
Depot
Hop Garden Plantation
Old Parsonage
Stones
Towing Path
Coxmoor Bridge
265
Hancock's Farm
283
Coxmoor Wood
Falkner's Copse
Leeches Copse
Ashen Row
Small Acres Farm
Peaked Croft Copse
Shucks Copse
Five Acre Copse
Oakes Copse
Six Acre Copse
Little Pains Hill Copse
Goose Close
Bowenhurst Lane
Long Moor Plantation
Mill Lane
Bowenhurst Farm
Brown's Row
The Plough (P H)
280
RYE COMMON
274
253
Odiham 3
Farnham 4½
Old Mill Cottages
Lodge
Great Rye Farm
Tanks
266

Photograph 49. The siting of Fleet substation in Coxmoor Wood has provided complete and effective screening from all public viewpoints. This view was taken within the wood in a small area cleared to permit erection of the overhead line.



Map 45 showing location of Bishops Wood 275/132 kV substation, Worcestershire which although sited on the crest of a small hill is effectively screened from all the nearby houses.

Map 46 showing location of Seven Springs 400/132 kV substation in Gloucestershire which is situated in the Cotswold Area of Outstanding Natural Beauty and is probably the highest of the Board's substations being situated between the 800 and 900 ft. contour. This site being on the fringes of Hilcot Wood was favoured by the Local Planning Authority who granted planning permission without requiring any additional landscaping of the site.

This is the nett area of the enclosed compounds and this area is increased depending upon the length of access road, land required for ground modelling, tree planting as well as any land used for the terminal towers and cables.

An attempt has been made to find out the actual area of land acquired for primary substation sites but this has presented some difficulties (26) A schedule of substations, and their total acquisition area is included in Appendix J.

A combined 275/400 kV substation of which there are nearly a 100 in England and Wales would require on average about 40 acres of land. As a national policy the Board endeavours to keep the amount of land it purchases to the minimum in order that the smallest amount of land would be taken out of beneficial agricultural use. It does sometimes happen that a landowner asks the Board not to purchase just that part of the land they require, but to take all the holding in order that he may move elsewhere and start farming again. The writer knows of no case when the Board has refused this request.

The majority of planning permissions for substations impose a condition requiring landscaping, and the extent of land for this purpose can vary considerably. The Board seems to be anxious not to exercise its statutory power to acquire land compulsorily but has done so in at least four cases. (27) When a compulsory purchase order is proposed there seems to be a tendency to reduce the area of land for landscaping. There is no doubt that compulsory powers may be exercised, both for the site of the actual substation, as well as for any land that may be required for landscaping. In the former case however, the area required may be precisely calculated on the basis of the equipment it has to contain. In the latter case the need for landscaping, and its extent is a subjective matter which may vary greatly depending whether one is the objecting landowner, the Board, the Local Planning Authority, a nearby resident, or the Local Amenity

Society. For the Board to determine the minium area to purchase compulsorily is a matter of fine judgement between all these often conflicting interests.

A recent C.P.O. case concerned a proposed substation site at Hop End near Amersham, Buckinghamshire. (28) In the first instance the Board wished to acquire about 108 acres in order to carry out extensive ground modelling to screen the substation; after which the larger part of the land would have been reinstated and returned to the former owner. The landowner who strongly objected to the proposed substation reinforced his objection by opposing the purchase of such a large area of land. This view was upheld by local residents, The Council for the Preservation of Rural England and the National Trust, and the Board felt obliged therefore to reduce the extent of the landscaping originally proposed so that the amended site came to 53 acres. This was made up as follows:-

400 and 132 kV compounds	23 acres
Earthwork embankments, tower and cable reserves and access road.	16 acres
Area required for landscaping	14 acres
	53 acres

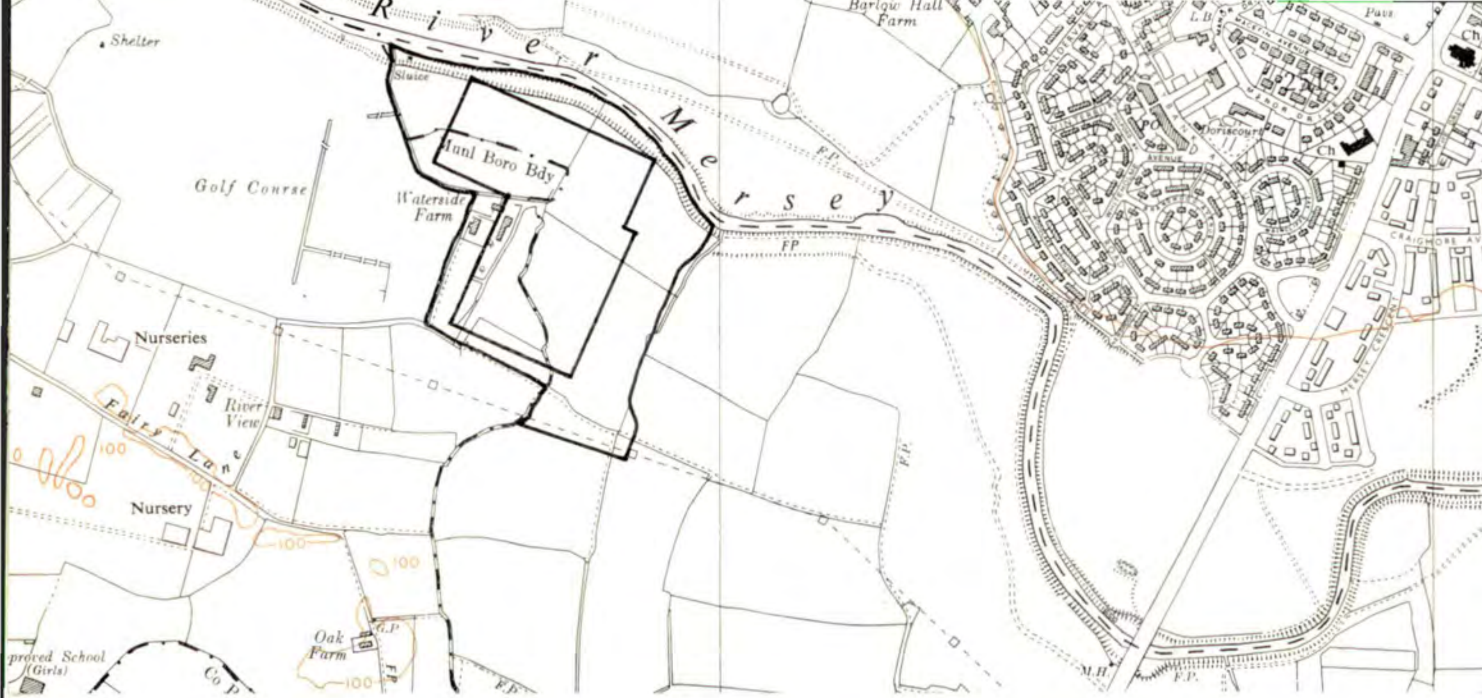
An average size 275/400 kV substation occupying 50 acres of land would cost about £3.5m which represents a capital investment of £70,000 per acre. This figure would be increased to over £100,000 per acre in respect of the land occupied by electrical equipment. This high capital investment is not always appreciated, and the Board in its desire not to use its compulsory powers has sometimes incurred considerable extra expense.

In 1964 the Board was in consultation with the planning committee of Manchester and Sale for permission to construct a 275/132 kV transforming station. The Board had prepared several alternative layouts of the proposed substation which had been submitted to the respective planning

Committees, but they were all subject to objection for the reason that the substation would encroach on an area occupied by piggery small holdings. The planning committees stated that such an encroachment would affect the livelihood of the smallholders, and therefore the Board should consider some other arrangement so as to avoid this disturbance. The only way the Board was able to reduce the overall length of the substation and avoid this objection was by installing a cable tunnel between the 132 kV and 275 kV compounds instead of laying them direct into the ground. (29) This enabled the substation length to be reduced by 45 feet which was sufficient to enable the planning committee to grant permission. The extra cost to the Board which must be measured in many tens of thousands of pounds seems to be a very high price to pay for the retention of a few feet of a piggery smallholding.

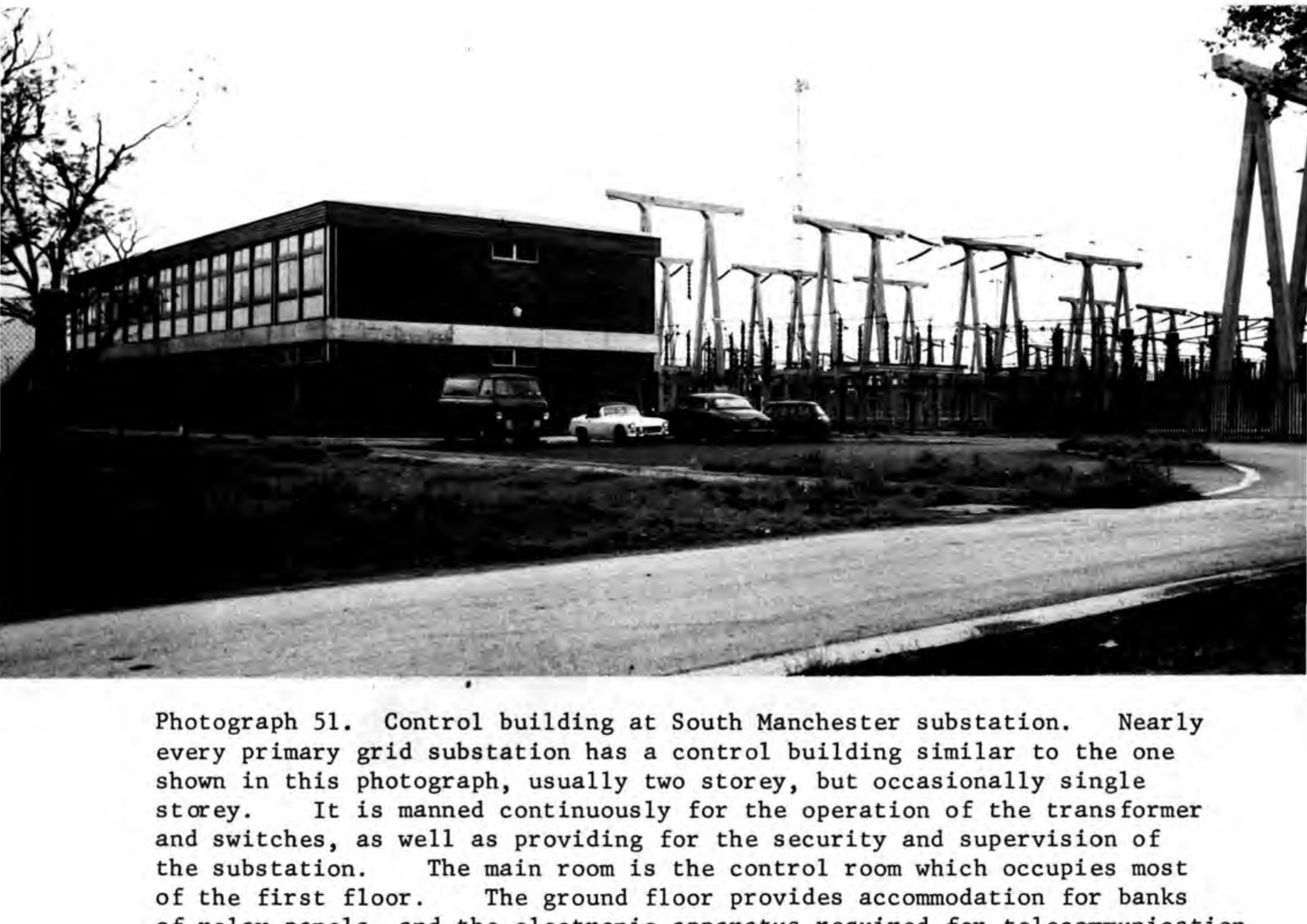
8.6 Conclusion

The Board has built, or is in the process of building about 130 primary supergrid 275 kV and 400 kV substations, which would have involved the acquisition of approximately 5,000 acres of land. Of this area, over half of it would be covered with granite chippings, gravel, and electrical equipment, and devoid of any form of vegetation. Steel structures up to 70 feet high, and a mass of other equipment, make these substations very difficult to fit into either urban or rural areas, and the general opinion seems to be to try and screen them by setting the substation at a lower level, and creating earth banks and tree planting. The development by the Board of an electrical arrangement that reduces the overall height of a substation has been welcomed by Local Planning Authorities and Amenity Societies, but so far as is known only two substations out of about 130 will be built to this new design. It is a matter of regret that the revised design which is such a visual improvement should have arrived so late in the supergrid construction programme. It is thought that probably



Map 47 showing location of South Manchester 275/132 kV substation on south bank of River Mersey adjoining the boundary with Cheshire.

Photograph 50 showing site of South Manchester substation before construction, and the piggery smallholdings the retention of which required an expensive modification to the substation layout.



Photograph 51. Control building at South Manchester substation. Nearly every primary grid substation has a control building similar to the one shown in this photograph, usually two storey, but occasionally single storey. It is manned continuously for the operation of the transformer and switches, as well as providing for the security and supervision of the substation. The main room is the control room which occupies most of the first floor. The ground floor provides accommodation for banks of relay panels, and the electronic apparatus required for telecommunication with national control in London, and a local area control in Manchester.

not more than a dozen substations will eventually be built to this improved design.

There seems little doubt that the electrical requirements for the siting of substations are the dominant factors, on the grounds of economy. The cost of the electrical equipment, and overhead lines dictate fairly precisely the optimum economic location. Any extra costs of land acquisition, additional civil works, because of extended access roads or poor soil conditions, or landscape treatment; incurred at the optimum electrical site would be easily exceeded by even a modest movement away from the optimum electrical position.

The Board generally seems to show little practical regard to either land use, to Green Belts or other forms of protected land, although a few exceptions have been mentioned in this chapter.

The fact is, that all but eleven out of approximately 130 sites obtained planning permission from the Local Planning Authority. The remaining eleven sites went to public inquiry which were subsequently allowed by the Minister. This tends to confirm that the Board is probably right in their policy of the simple and direct economical approach to the problem of substation siting.

In recognising that the Board is acting in accord with the statutory requirement to provide 'an economic supply' one may feel that the evidence suggests that their equal statutory duty to pay regard to amenity shows only a partially successful approach.

CHAPTER EIGHT

References

1. There are a few very minor exceptions to this general statement which will be apparent on referring to the Map in the pocket at the end of this volume. These exceptions are the small hydro stations at Chagford, Marytavy and Morwellham in Devon, a total generating capacity of only 5 MW. It is understood that they are all scheduled for closing down in the near future.

2. These photographs were prepared for the purpose of presentation at a public inquiry into a proposed substation site at Mop End near Amersham. Only a prototype aluminium bridge structure had been built at this time and the lower photograph is a montage based on the other photograph but altered to give an artists impression of the visual effect of the new design. The credibility of the lower photograph may be in some doubt but there is little doubt that the 42 ft. high aluminium structure will be a considerable improvement visually over the 70 ft. high steel gantries. So far as is know the only places that the new design will be used is at Mop End, and at Wymondley in Hertfordshire.

3. Report dated 30th November 1967 reference EL72/16/A35 by Mr. W.L.M. French, Deputy Chief Engineering Inspector Ministry of Power following a public inquiry from 22nd to 31st August 1967 into objections to a Compulsory Purchase Order for a substation site at Mop End near Amersham. Page 13, para. 48 and Page 15, para 60.

4. There are two in the Liverpool area at Frodsham and Rainhill, and also at Kearsley near Manchester, and another at Whitson in Monmouthshire.

5. Daily Telegraph 29.9.65.

6. The substations at Nursling in Hampshire, and Walham in Gloucestershire, were both raised several feet by importing filling material, but the additional cost of this work is not known.

7. New access roads of a quarter mile long are fairly frequent; an access road of just under a mile to Cowley substation, and a mile and a half to Bramford substation in Suffolk are rather exceptional. The extent to which local authority roads are widened and remade purely for the purpose of enabling the delivery of transformers is not known, but some work is probably required at every substation site.

8. Only four instances are known of the Board exercising its powers of Compulsory Purchase for a primary substation site. These were at Feckenham Wymondley, Berkswell and Mop End.

9. The Electricity Act 1957 Section 37 obliges the Board to pay due regard to amenity, the full text is included as Appendix G. This requirement has recently been extended to all statutory authorities in Section 11 of the Countryside Act 1968, the full text being included as Appendix H.

10. Other supergrid substations whose locations have been largely determined by the presence of a small existing substation are at Elstree in Hertfordshire, Penwortham in Lancashire, West Boldon in Durham and Wymondley in Hertfordshire.

11. The complete list is included as Appendix I.

12. White land is defined as "land for which the existing use should for the most part remain undisturbed".

13. These were:- Feckenham, Mill Hill, Pentir, Osbaldwick, Bredbury, Legacy, Birkenhead, Wymondley, Chickerell, Burton Green (now renamed Berkswell) and Mop End.

14. Refusal by Warwickshire County Council Application No. 17980 dated 8th September, 1965.

15. The inquiry was held at Coleshill 12th, 13th, 18th and 19th October, 1966.

16. Report by Mr. Charles Johnson FRICS. Inspector Ministry of Housing and Local Government reference 2243/A/8659 dated 12th December, 1966, Page 18, para. 91.

17. Minister of Housing and Local Government decision letter reference P14/APP/2243/A/8659 dated 22nd June, 1967.

18. Report dated November, 1967 by Mr. A.G. Harcourt Senior Inspector Ministry of Housing and Local Government following a public inquiry at Amersham from 22nd to 31st August, 1967. Page 15, para. 71(i). The Minister's decision is not known at the present time.

19. This resulted in a public inquiry which was held at Birkenhead on 29th October, 1964.

20. Report by Mr. A.E. Rochard - Thomas, A.R.I.C.S., M.T.P.I., Inspector Ministry of Housing and Local Government reference APP/854/A/83516 dated 27th November, 1964.

21. Decision letter from Minister of Housing and Local Government reference APP/854/A/83516 dated 29th December, 1964 and fully reported in Birkenhead News 2nd January, 1965.

22. Examples of enclosed substations in the Greater London area are at Wimbledon, Hackney, St. John's Wood and Willesden.

23. Span September 1967, Page 5 and Span December, 1968, Page 11. This substation is due to be commissioned in July, 1969.

24. Pattern of Power - C.E.G.B. publication 1963, also Electricity and the Land - C.E.G.B. publication 1962.

25. See photograph 20 for the case at Cowley substation where tree felling for an overhead line entry into the substation destroyed the remaining peripheral tree screen of the wood.

26. Very few supergrid substation sites are yet shown on large scale ordnance maps, and there is no published source that provides this information except in the very few cases of an Inspectors report following a public inquiry. All other areas were obtained by a personal inspection, the boundaries transferred to a 1 : 2500 ordnance sheet, and the area calculated. It is readily acknowledged that this method may not be absolutely accurate, but is considered adequate for the purpose of this chapter.

27. These were at Feckenham, Wymondley, Berkswell and Mop End.

28. Report dated 30th November, 1967 reference EL72/16/A35 by Mr. W.L.M. French. Op.cit.

29. The technical details of the construction of this cable tunnel are explained in an article, Experiments on Detection of Insulating Oil Fires in a Cable Tunnel by K. Reed and P.W. King. Span June 1968.

CHAPTER NINE

Case Study - A Substation in South Buckinghamshire

9.1 Introduction

The previous chapter dealt with the main considerations influencing the selection of a site for a large electricity substation and it would be an interesting study to see how far these considerations are valid, and the weight given to them in a specific situation.

There are difficulties in selecting a substation for the purpose of examining the various factors that led to its location, becasue one cannot be sure that it would be typical; and the tendency would be to choose one that had some exaggerated features. Nevertheless if the site selected for detailed examination has been well documented, it at least presents the opportunity of extracting more reliable facts upon which to draw some conclusions.

One such site was the subject of a proposal by the Generating Board to establish a 400/132 kV substation at a hamlet called Mop End, near Amersham in South Buckinghamshire. The site the Board selected was vigorously opposed, which resulted in two public inquiries and much press comment. This case was particularly interesting as the proposed site was situated in an area of outstanding Natural Beauty, and the costs of alternative sites was much

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Note:- Map 50, an extract from 1" O.S. Sheets 159 and 160 has been included at the end of this chapter. The map has been so arranged that it may be left unfolded during the reading of this chapter which may be helpful in identifying the location of the several sites referred to.

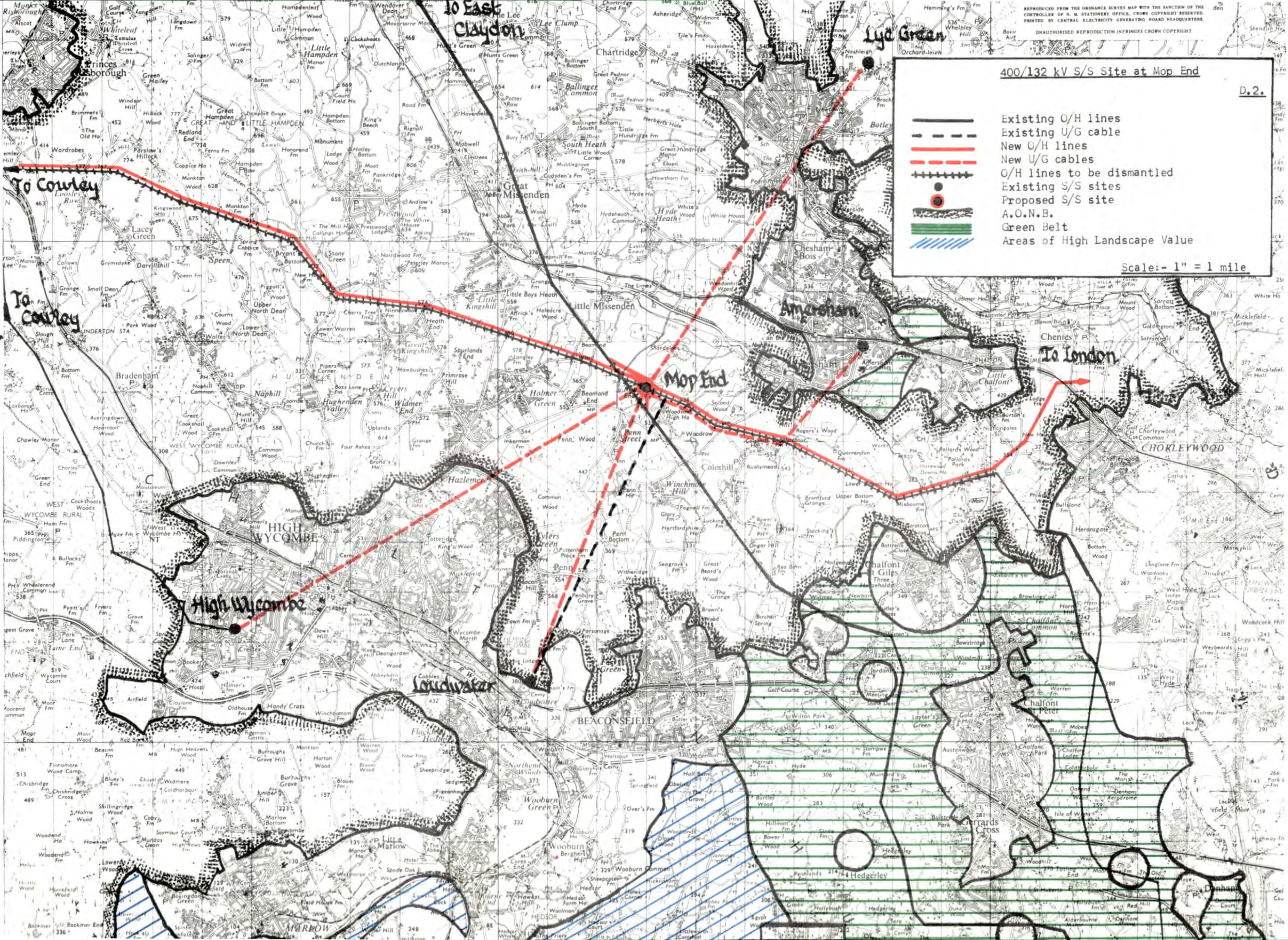
debated. The question of what value to put upon beautiful landscape was argued most eloquently as well as the electrical justification for the need for a substation. It is thought therefore that the case of Mop End is worth a careful study. (1)

9.2 The Case for the Generating Board

Sometime in 1964 the Generating Board decided that it required a substation site in South Buckinghamshire to obtain a major source of power from the supergrid in order to reinforce electricity supplies in that area.

The Board's system design engineer initiated the search for a substation by defining the objectives that the proposed new substation was to achieve. He has said in evidence that the substation should be suitably located to take the electrical demand immediately off of the three existing 132 kV transmission lines which run to High Wycombe, Loudwater, and to Iver. This was to be achieved with a minimum of new 132 kV overhead lines or cables. The major centres of demand are concentrated in the Chesham - Amersham, and High Wycombe - Beaconsfield areas. (2) The substation was required to be located between these towns in order that future transmission connections could be made with minimum cost and effect on amenity. The substation should also be located in a position which enabled the greatest use to made of the existing lines and should be located as near as possible to the existing 400 kV line route, to avoid the need for additional 400 kV lines in the area.

The substation should if possible be sited where it could be effectively screened by landscaping and where the overall impact on amenity of substation and associated transmission lines were kept to a minimum. It was also necessary to have in mind the possibility of a new 400 kV transmission line between Cowley and North West London, and its connection to its existing 400 kV line, (3) shown diagrammatically on Map 48.


REPRODUCED FROM THE ORDNANCE SURVEY MAP WITH THE SANCTION OF THE CONTROLLER OF H. M. STATIONERY OFFICE, CROWN COPYRIGHT RESERVED. PRINTED BY CENTRAL ELECTRICITY GENERATING BOARD HEADQUARTERS.
UNAUTHORISED REPRODUCTION INFRINGES CROWN COPYRIGHT
400/132 kV S/S Site at Mop End
D.2.
Existing O/H lines
Existing U/G cable
New O/H lines
New U/G cables
O/H lines to be dismantled
Existing S/S sites
Proposed S/S site
A.O.N.B.
Green Belt
Areas of High Landscape Value
Scale:- 1" = 1 mile
To East Claydon
Lye Green
To Cowley
To Cowley
Amersham
Mop End
To London
High Wycombe
Loudwater

Map 48

The Board's engineer said that the search for a substation site with these technical requirements would logically start where the 400 kV East Croydon to Iver line crosses the 132 kV Cowley to Iver line, and the Board's Officers have said that they reaslised from the outset that it would be extremely difficult if not impossible to find a site which did not have some effect on amenity and cause offence, because the optimum electrical location was within the proposed Chilterns Area of Outstanding Natural Beauty. (4)

The Board investigated seven sites (5) and from considerations of visual amenity and possibility of concealment in association with the overhead lines they preferred a location at Mop End with a practical alternative at Owlsears Wood. The Board had discussed all these alternatives with officers of the County Council and the Rural District Council and had gained the impression that the Mop End site was also preferred by them as the least objectionable.

On 1st August, 1966 an outline planning application was made to Amersham R.D.C. for the Mop End site, situated on the north side of the Rough Park, which would have involved the purchase of about 110 acres of land. (6) This large area of land for a 30 acre substation was proposed in order to carry out extensive earth works to provide immediate physical screening of the site from all directions. It has been intended that the greater part of this land would have been returned to agricultural use for arable or grazing soon after the completion of the ground modelling. There was however considerable objection to this proposal because of the large area of land involved. At the request of the Buckinghamshire Branch of the C.P.R.E. a meeting was held with the local residents at Mop End, representatives of the landowner, the C.P.R.E. and the National Trust. Preference was expressed for a revised proposal to take greater advantage of the adjoining woodlands. This resulted in an overall proposal which reduced the acquisition area to about 53 acres, made up of 43 acres of woodland, 9 acres of arable and about 1 acre of pasture. (7)

Following this amended proposal for Mop End, discussions and consultations took place with the County and Area Planning Officers, the Clerk and Surveyor of Amersham R.D.C. the C.P.R.E., the Forestry Commission, County Surveyor, Agents for the landowner, as well as interested local residents at Mop End. The Board also arranged a visit to a similar substation, and they have said that all observations and suggestions made at those meetings were noted, and where practicable incorporated in their amended proposal which was submitted for planning permission.

Following these consultations the Chiltern Society wrote to the Board:-

> "We fully recognise the great care with which the Central Electricity Generating Board have sought a site which will be as inoffensive as possible. It may well prove to be the case that Mop End is the right place for the substation." (8)

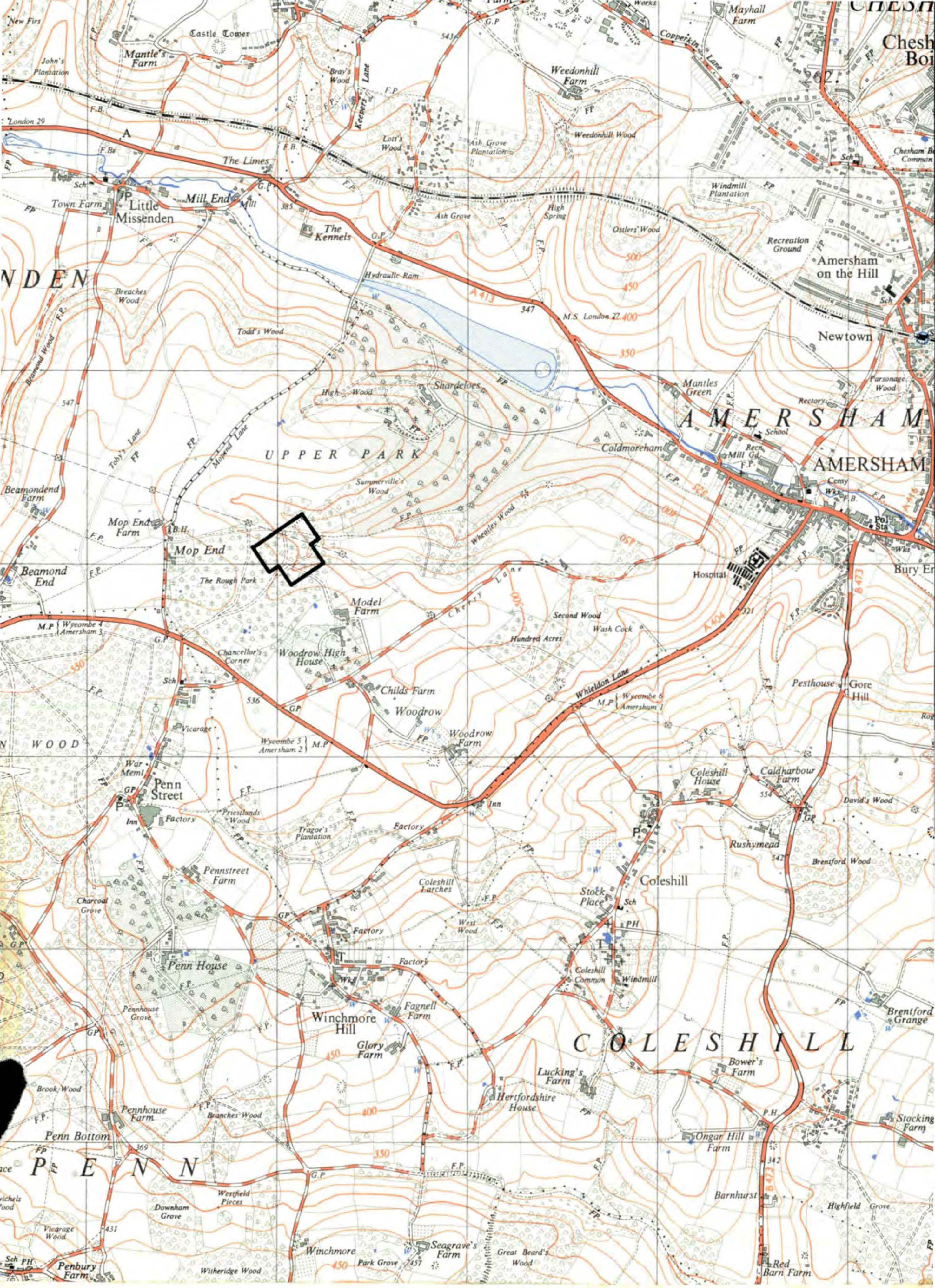
As Mop End is within the Chiltern's A.O.N.B. the National Parks Commission were formally consulted and in their reply to the Board said:-

> "We think the Commission would take the view that it would be difficult to find a less obtrusive site for this substation than the one proposed and, although the 400 kV line itself cannot be concealed, the substation will have the least damaging effect on the landscape that is possible. It is to be hoped, however, that in order to ensure that the fullest benefit is obtained from the existing woodlands, the amount of tree felling is kept to the minimum that is essential."(9)

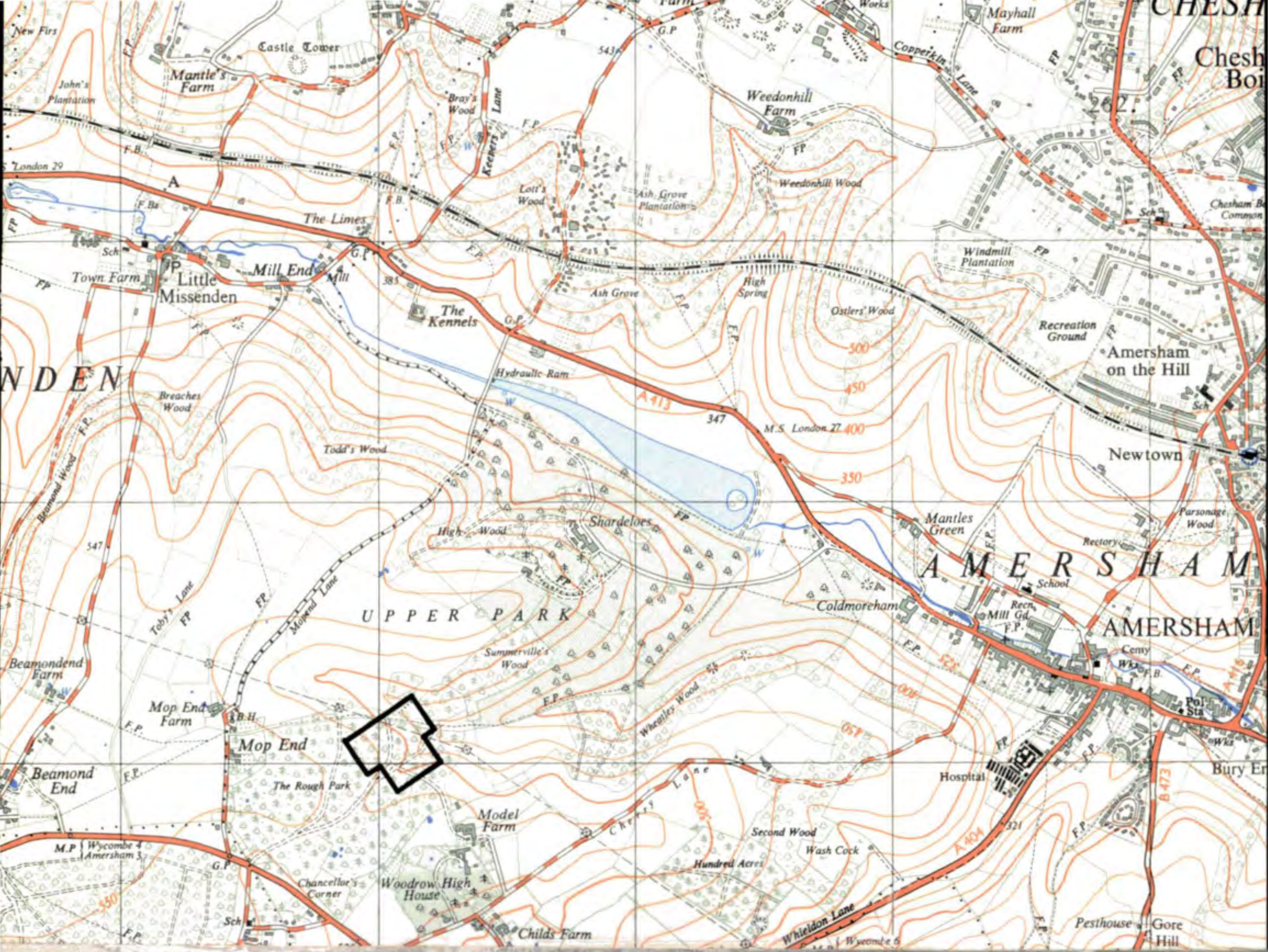
Despite these consultations and observations the Amersham Rural Council and local organisations sustained their objections, and planning permission was refused. The Board lodged an appeal against this refusal and a public inquiry was held. (10)

At this inquiry the Board's witnesses attempted to demonstrate that they had gone to a lot of trouble to consider the effect of amenity of the site at Mop End. A set of air photographs, (11) site photographs (12) and a model were exhibited, (13) a selection of these photographs and of the model are included on the following pages.

Photograph 52. Air oblique view eastwards of proposed South Buc
substation with extent of electrical compounds outlined.

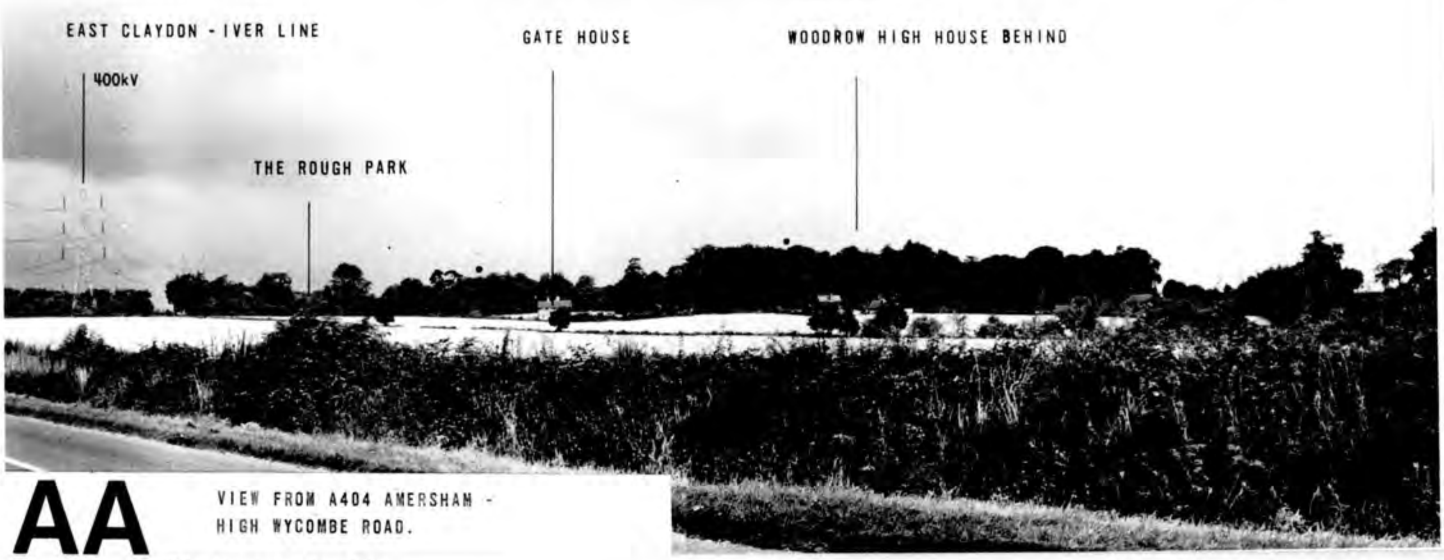


Map 49. Showing location of proposed S. Bucks substation enclosed by woodlands and sited near the head of a shallow valley across the 500 ft. contour.

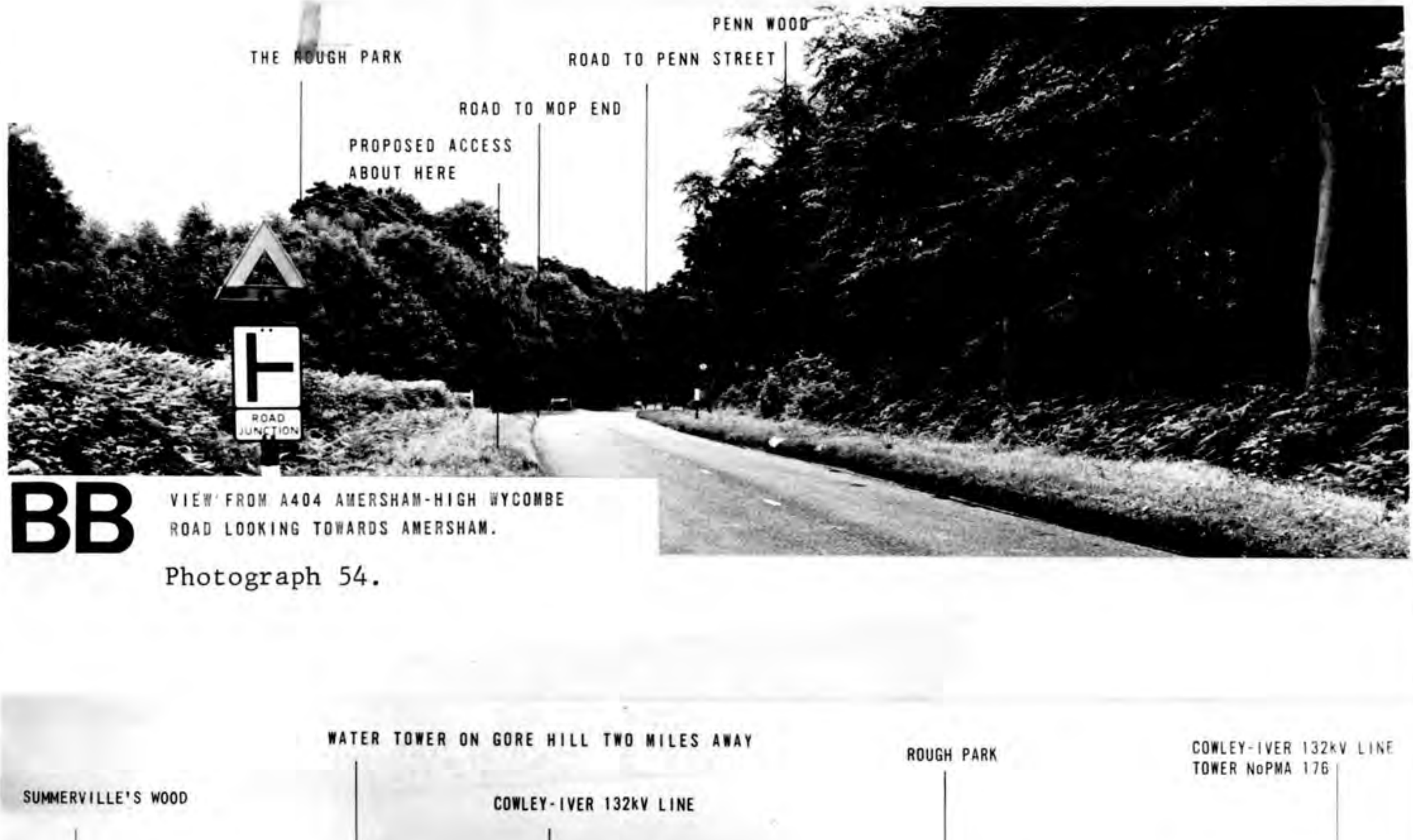


Photograph 52. Air oblique view eastwards of proposed South Bucks substation with extent of electrical compounds outlined.

Map 49. Showing location of proposed S. Bucks substation enclosed by woodlands and sited near the head of a shallow valley across the 500 ft. contour.

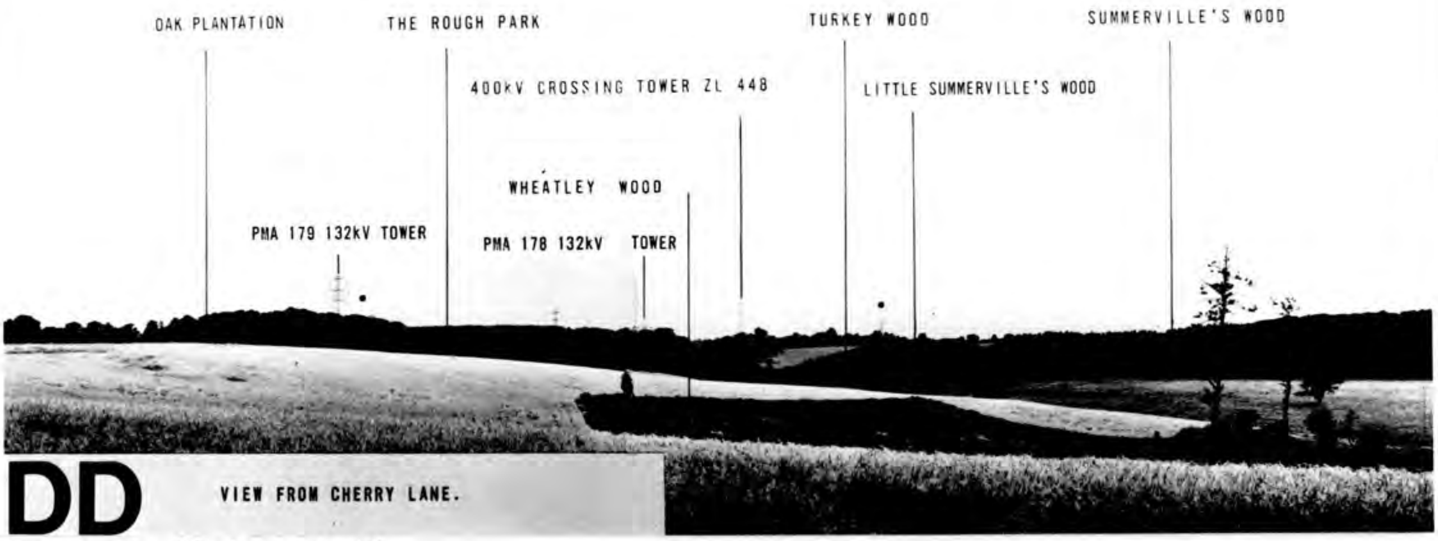


Photograph 53.

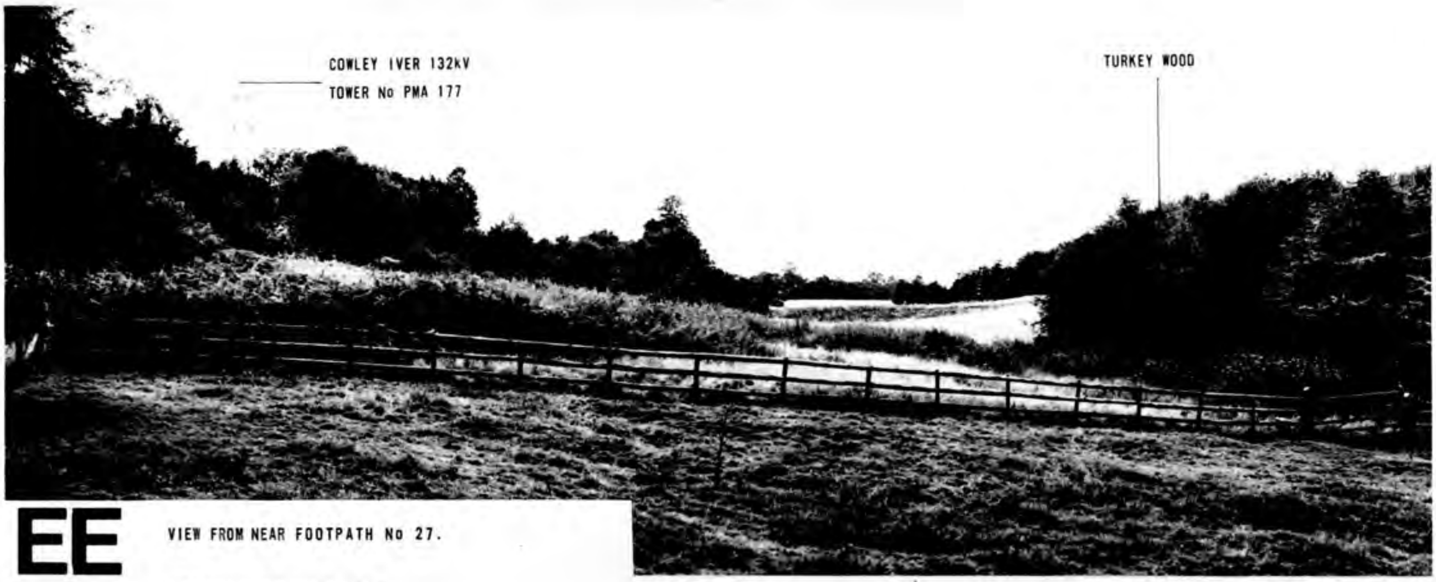


Photograph 54.

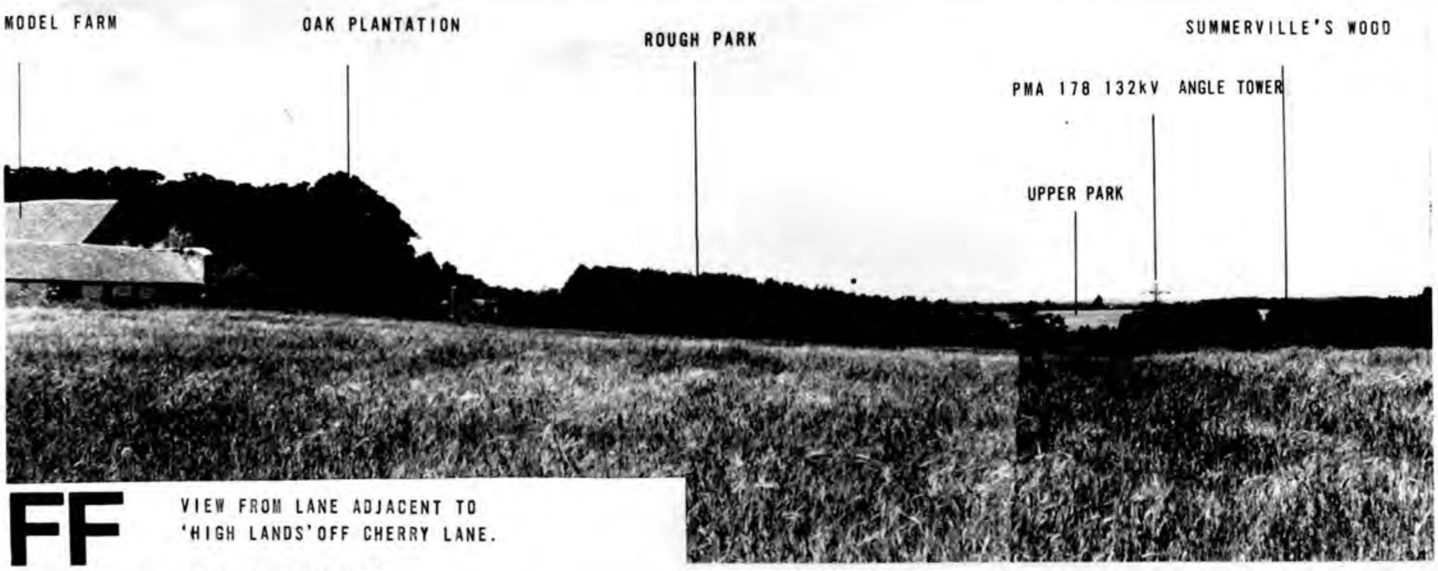
Photograph 55.



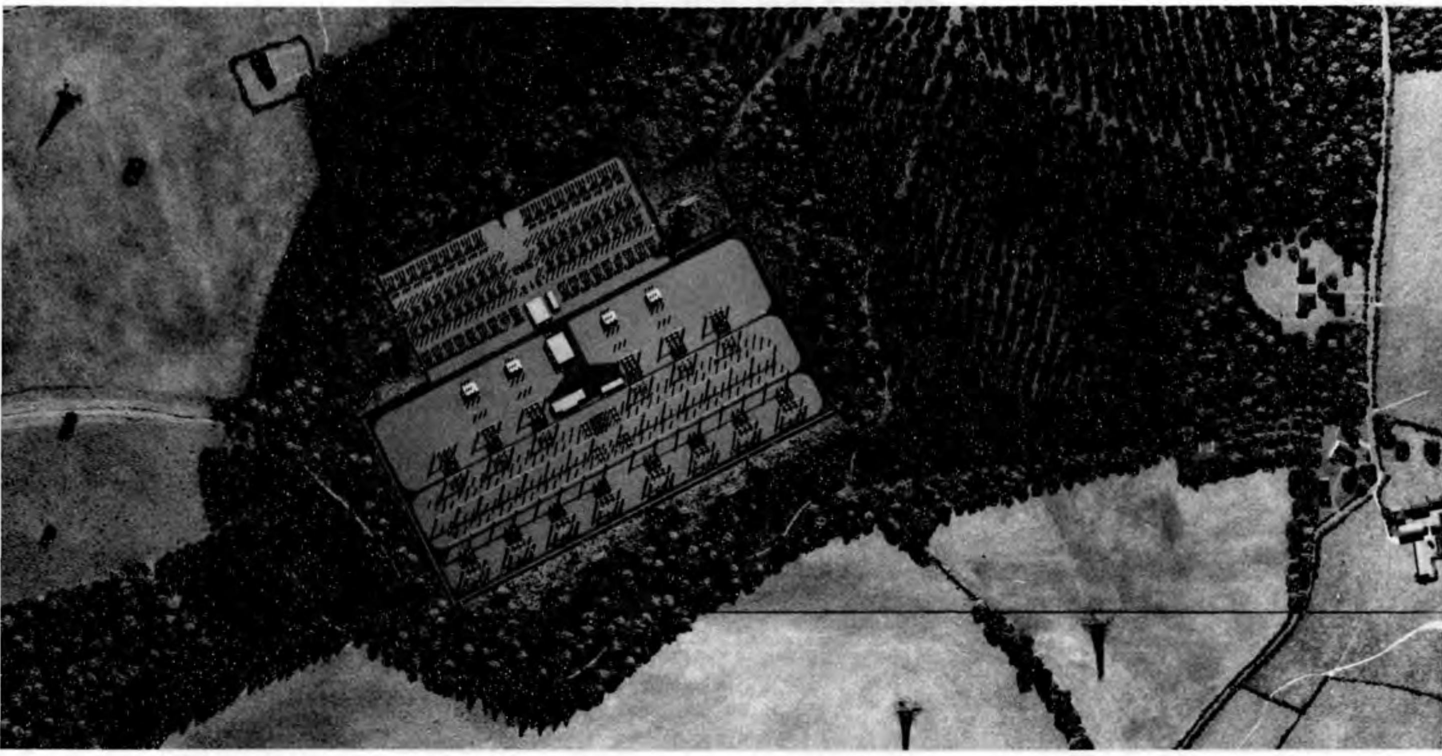
Photograph 56.



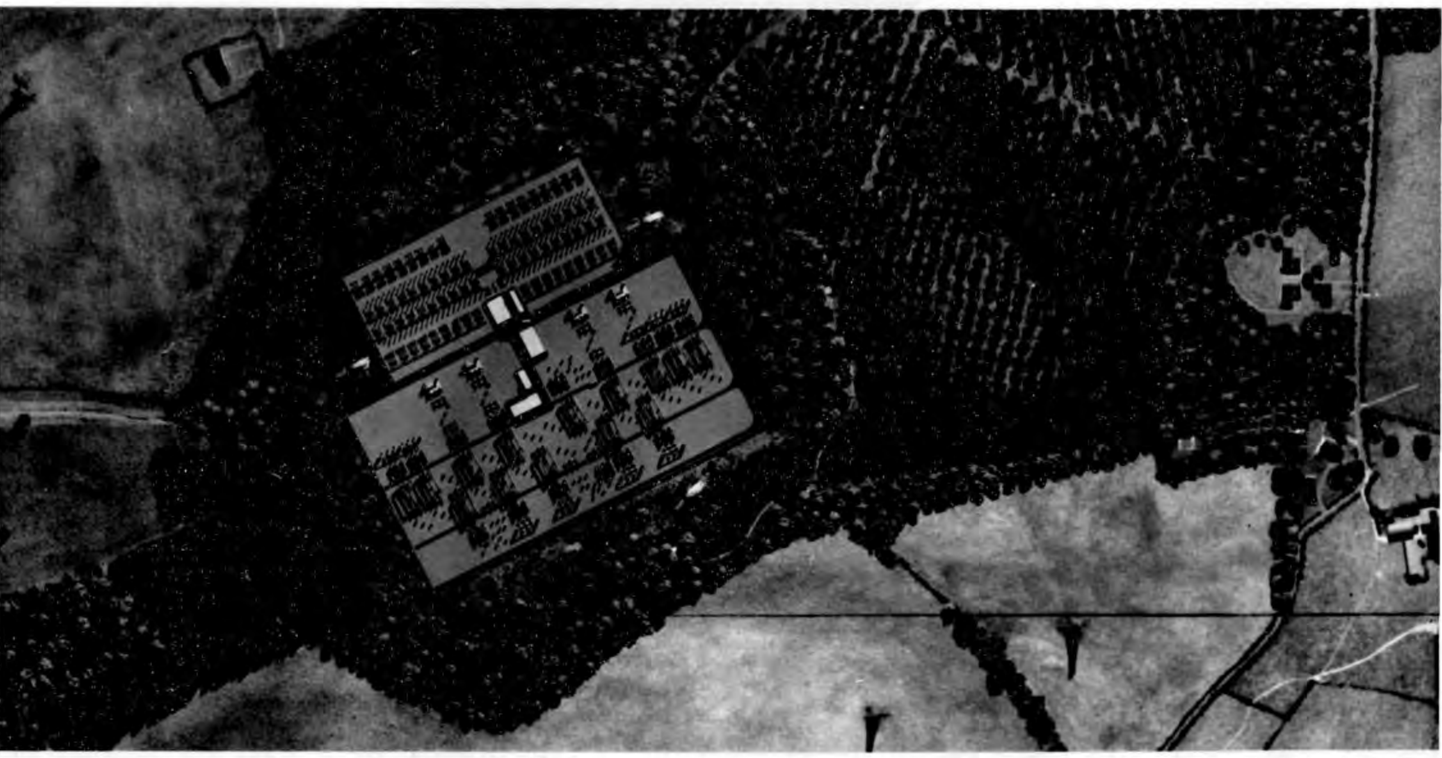
Photograph 57.



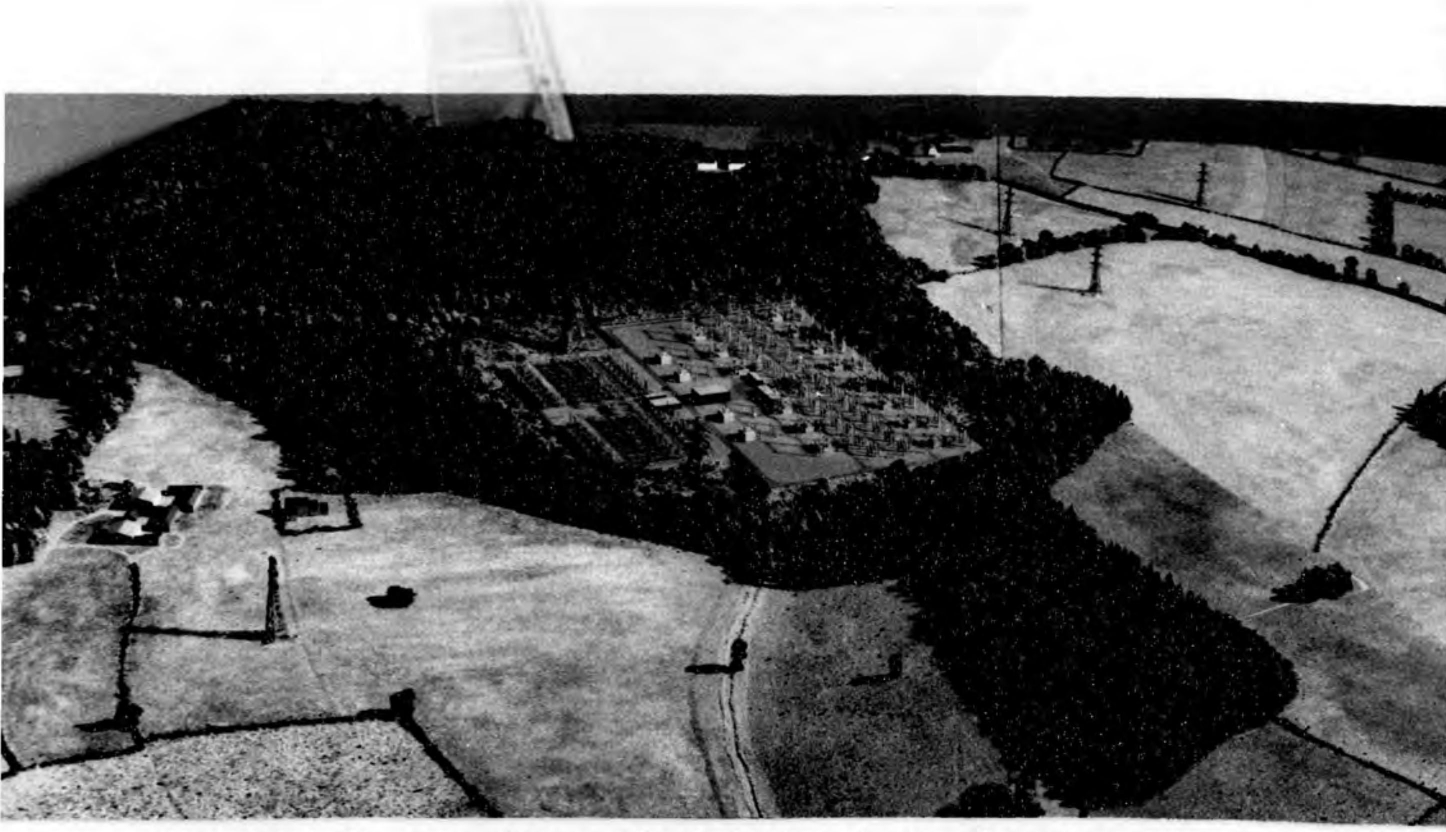
Photograph 58.



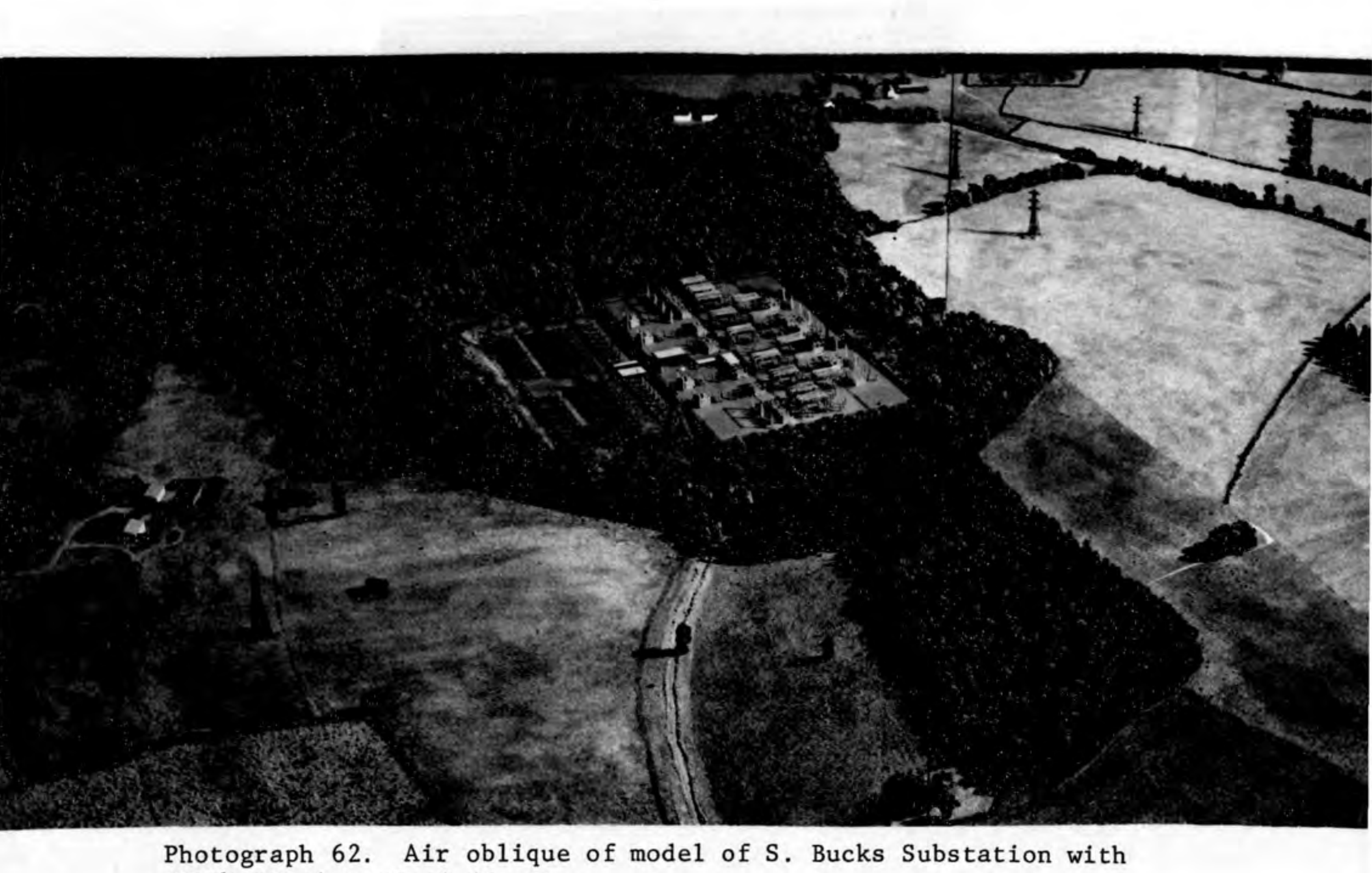
Photograph 59. Plan view of model of S. Bucks substation with Mark I electrical layout.



Photograph 60. Plan view of model of S. Bucks substation with Mark II electrical layout.



Photograph 61. Air oblique of model of S. Bucks substation with Mark I electrical layout.



Photograph 62. Air oblique of model of S. Bucks Substation with Mark II electrical layout.

The appeal site was situated on a comparatively high part of this undulating countryside, and the formation level of the substation would be about 500 ft. above ordnance datum. The presence of the existing trees of about 70 ft. high would give excellent screening as well as providing a background to the substation equipment. The orientation of the compounds was arranged to take the greatest advantage of the contours and to provide the greatest benefit from the earth moving operation of cut and fill by establishing the substation floor at the lowest practicable level. The precise position of the substation was also influenced by the desire to site the installation at the greatest distance from the houses at Mop End to the west and those at Woodrow to the south.

The Board said that before any consultations took place about the site at Mop End the whole of the surrounding area had been carefully investigated and six other possible sites considered. (14)

Site number 1 at Featherbed Lane, Holmer Green, site number 2 to the north-east, and site number 3 north of Mop End Farm are all on exposed high ground above the 500 ft. contour line and would be visible from residential development at Holmer Green, Beamond End and Mop End, and clearly visible from Little Kingshill and the Missendens. The line entries, for each site, would be much more obtrusive than for the Mop End site. Site number 4 in the Rough Park is on the highest part of the woodland area and the necessary line entries would have necessitated the felling of many tall trees thus reducing the screening of the substation. Site number 5 at Mantle's Farm, Little Missenden is on the north side of a railway embankment and a considerable amount of cut and fill would be required to form the substation floor, and in consequent the railway embankment would not afford an effective screening. The overhead line entries to this site would be very prominent and it seemed unavoidable that there would be three overhead lines crossing the A413 road in close proximity. Two of these lines would be close together around Little Missenden and this was also considered to be most undesirable.

In the early stages of consultation Site No. 7 at Owlsears Wood seemed to find some favour with the county and district representatives. If one regarded merely the substation itself this would have been a good site as it is on low ground below 350 ft. A.O.D. and is not unduly close to many residences. One disadvantage would perhaps have been the interference with numerous footpaths in the area, but the more serious objection to the site seemed to be because of the overhead line diversions which would be required.

All these alternative sites are within the Chilterns Area of Outstanding Natural Beaty. No other sites had been suggested during the period of construction by either the County Council or Local Authorities, and although in refusing the Board's application one of the grounds was that "The Planning Authority were not satisfied that the substation cannot be sited outside the A.O.N.B." they had not suggested any such location. The Board were confident that there was no site other than that chosen, even outside the A.O.N.B. which would have a less injurious impact on amenity generally.

One objector during the course of the inquiry suggested a further six alternative sites which were all situated outside the Area of Outstanding Natural Beauty. (15) The Board's officers said that all of these sites were technically possible but they were not able during the course of the inquiry to give a fully considered opinion from all aspects of amenity cost and detail design. All of these sites were along the route of the existing East Claydon/Iver 400kV line towards Iver, including one at Iver.

All of them were in the green belt and had disadvantages in the development of the 132 kV system and the connection of a possible future 400 kV line.

The Board in commenting upon these suggested sites said that having regard to the necessity of reinforcing the electrical supply in the areas of Chesham - Amersham and High Wycombe - Beaconsfield, the further a site was moved along the route of the existing East Claydon to Iver 400kV line towards the substation at Iver, the greater became the technical and economic disadvantages, and the amenity problems. Electrical reinforcement from Iver substation or nearby, did not meet the electrical design parameters laid down by the Board's system design engineer. It was remote from those areas requiring an electrical supply and did not make use of the existing 132 kV lines, it was also uneconomic to transmit electrical power into Iver substation, transform it down and then bring it out again to the required areas.

A study was made by the Board of an alternative scheme of electrical reinforcement, whereby the electrical demand from the Amersham= and Beaconsfield areas would be supplied from the suitably enlarged existing substation at Iver. This alternative would involve taking 132 kV lines through the Metropolitan Green Belt between Iver and Loudwater through an area of some beauty, and through the built-up area between Watford and Hemel South. To provide a reinforcement system by 1980 comparable with the Mop End scheme, and assuming that the 132 kV line connection had to be put underground, the additional cost was said to be in the order of £3.4 million. This sum would be enough to pay for the whole of the 400 kV substation, the 132 kV substation and transformers required for local supply from the Mop End site.

The most promising site of those suggested seemed to be No. 8 adjoining Bulstrode Park located on a partly worked out gravel pit now in use as a rubbish tip, situated immediately south of the London to Oxford A40 road. This site is halfway between Owlsears Wood and Iver and is close to the existing 400 kV line, but it only meets two of the design requirements for the South Buckinghamshire substation location. It would not be suitably located to relieve the three overloaded 132 kV lines, and is not centrally located to the load centres. The connection to a possible future 400 kV line would result in a birdcaging effect of overhead lines to the north of the site.

The comparative cost of any site would depend upon the cost of civil works plus the cost of the necessary 400 kV and 132 kV connections. The cost of the electrical equipment would not affect the comparative costs between alternative sites as they would be about the same. The total costs for substation equipment, civil works, landscaping and associated transmission connections in the case of Mop End would be £3,399,000 by 1975 increasing to £11,472.000 by 1980. The cost of Owlsears Wood site would be £3,698,000 by 1975 and £12,154,000 by 1980.

The cost penalty of £682,000 resulting from the relatively short movement from Mop End to Owlsears Wood was almost entirely due to the extent of the secondary 132 kV connections and reflected the sensitivity of such movement; and that was why the Board had not searched for sites outside the Area of Outstanding Natural Beauty. This cost penalty concerned only the use of the substation for local supplies and had nothing to do with the cost of connecting the possible future 400 kV line.

In the case of site No. 8 Bulstrode Park, the civil engineering works were estimated to require an expenditure of £350,000 compared with Mop End of £241,000. The cost penalty was due mainly to the longer transmission connections and particularly the placing of long lengths of 132 kV line underground.

The Advocate summing up the Board's case said that taking into consideration all the factors that have emerged during the inquiry and recognising in particular the need to preserve as far as possible the general amenity of this part of the Area of Outstanding Natural Beauty, the Board was of the opinion that the choice of Mop End as a site to provide the 400/132 kV substation necessary to maintain the future electrical supplies to area was the correct one for the following reasons:-

"1. The site is in the centre of the area of load growth and therefore provides the optimum position both electrically and economically.

2. The overhead line modifications required have the least impact on amenity.

3. The site itself is for the most part woodland and with the exception of the north side will have the remainder of a large wooded area with its perimeter of well matured forest trees as an established screen for the substation structures. Furthermore, the rise in the contours to the north and the presence of the other nearby woodlands of Shardloes will afford a great deal of useful screening from that direction.

4. The site will be well screened not only by the existing but by the proposed additional landscaping from adjacent habitation and distant development of Amersham, Coleshill and the Missendens.

5. The most important factor to be taken into consideration is the position of the existing overhead lines which cross the A.O.N.B. and provide the means whereby the electrical supplies to the towns and villages in the North Chilterns area can be reinforced. I consider that the Board's aim to cause the minimum additional effect on amenity will have been achieved if consent is obtained for the Mop End site and the overhead line rearrangement to connect to it."

9.3 The Case for the Objectors

Opposition to the proposed substation site at Mop End was principally voiced by Amersham Rural District Council, supported by most of the local amenity societies. (16) The local papers also affected plenty of opportunity for critical comment on the proposal (17) and for the expression of local opinion.

The Amersham R.D.C. on the 2nd March, 1967 refused planning permission for a substation at Mop End for the following five reasons:- (18)

"1. The site is included within an area of high landscape value in the approved County Development Plan.

2. The site is included in the proposed extension to the Metropolitan and Local Green Belt which is intended to preserve a belt of open country around London and to pfevent the spreading and merging of the towns and villages within its boundaries.

3. The site is included within the designated Chilterns Area of Outstanding Natural Beauty.

4. Development of the type proposed, situated as it would be on the upper slopes of a valley running through the Chilterns, would have a major impact on the amenities of one of the most beautiful areas of county close to London, and would be visible from the surrounding countryside and, in particular, from nearby footpaths and highways.

5. The Local Planning Authority are not satisfied that the substation cannot be sited outside the Area of Outstanding Natural Beauty."

The objections to a substation at Mop End were vigorously persued, and the theme of each of the five reasons for refusal were extensively argued. The main case against the Board was that the proposed site was within the Chilterns Area of Outstanding Natural Beauty that the Minister of Housing and Local Government had so recently confirmed, (19) and to approve this site would be contrary to the Ministers intention to preserve this area of such landscape beauty. The Amersham R.D.C. put forward at the public inquiry six other sites that should be investigated all of which were outside the A.O.N.B. in the Gerrards Cross area, but nevertheless within the Metropolitan Green Belt. (20) The Board's officers took advantage of the late summer evenings to inspect these alternative sites, and gave evidence upon them during the subsequent days of the inquiry.

The spokesmen for the amenity societies and residents associations, supported the Councils objections by emphasising that they were not satisfied that sites outside the A.O.N.B had been seriously considered, and that any additional cost attributable to a site outside the A.O.N.B. would be an amenity cost justified to keep the A.O.N.B. free of this form of development.

9.4 The Inspectors Conclusions

The inquiry lasted for four days from the 22nd to the 25th August, 1967 followed by a further three days of inspection of the site and the alternatives. The Inspector's report (21) was published three months later in which he summarised the facts, and from them drew the following conclusions:-

He reported that the "dotted/ boundary (22) which was intended to indicate the trend of electrical demands at grid points in this part of Buckinghamshire did not strictly define the sphere of influence of the proposed substation over the years 1970 to 1980. The sphere of influence of the substation would change with the timing of the various reinforcements and, broadly speaking, by 1980, the substation would be supplying the whole of the "dotted" area. It was not possible to relate any other site to a particular geographic line shown on a map, as the fringe areas would change over the years because of the interconnection of the 132/33 kV grid substations with 33/11 kV substations, many of which spread out into the rural areas.

It was the power stations which provided the power to the national Supergrid, the purpose of the Supergrid substations being to transform and transfer that power. Any new Supergrid substation, wherever sited, was bound to affect the flow on existing transmission lines. It was technically possible to enlarge existing major substations outside the zone and transmit the power into it; but the Inspector concluded that it would be grossly uneconomic in this instance.

He said that the layout of the proposed substation at Mop End with its naturally well-wooded surroundings was such that the structures of the substation should be well hidden from general view. Given proper and sufficient landscape treatment, it should be sufficiently well screened, except from certain very local and limited view points, to make the site acceptable in this area from a visual amenity aspect. He had no doubt that the Board would do their utmost to carry out landscaping in accordance with their recommendations and the undertakings they had given. (23)

The Inspector commented that although the substation and its equipment would nestle into lower ground the site itself is on relatively high ground and it was therefore, the possibility of the sight of a number of overhead lines coming into and leaving the site that had given rise to concern. In view, however, of the undertaking given by the Board that, so far as development can be envisaged up to 1980, the 132 kV circuits associated with the Mop End scheme within the Chilterns Area of Outstanding Natural Beauty would be placed underground, he considered that this went a very long way towards meeting that objection.

From an engineering point of view, he considered that the Mop End site had considerable advantages. Other sites in the Chilterns Area or within the green belt would not escape some injury to visual amenity and there was the cost advantage of Mop End to weigh in the balance, and also the impact of overhead lines upon visual amenity associated with the development at any of the other sites put forward.

The site at Mop End was well located to take the electrical load immediately off the existing 132 kV lines feeding the area, and it would required a minimum of new 132 kV overhead lines, or alternatively, costly 132 kV underground cables for the future transmission reinforcements of the major centres of load in the areas of Lye Green, Amersham, Chesham and High Wycombe, Loudwater, Beaconsfield. It also makes the best use of the existing 400 kV and 132 kV transmission lines because of its location right at the point of crossing of the existing East Claydon, Iver 400 kV line and the existing Cowley, Iver 132 kV line. The diversion of these overhead lines into Mop End compared with any of the other sites could be done with the minimum amount of new line.

The Inspector also thought it was significant that if the Board were unable to find new sites for generating stations in the London area, a future 400 kV line from Cowley towards north-west London would be advantageous for the purpose of importing electricity generated in the Midlands. Evidence was given on the technical and economic advantages for turning in such a line at Mop End which would then realise the full potentiality of the site. The existing 132 kV Cowley to Iver line within the Chilterns Area of Outstanding Natural Beauty could be dismantled and the route occupied by the future 400 kV line without increasing the number of overhead lines in that Area. It was admitted that this would involve the introduction of a larger type of construction in place of a smaller one, but the Inspector agreed with the Board's view that this was preferable to routeing a new 400 kV line south of High Wycombe and through the High Wycombe valley towards London. Such a route, in any event, would have to pass through a substantial part of the Chilterns A.O.N.B. between Saunderton and High Wycombe. Even if a future 400 kV line should not be routed via Mop End, the Inspector was satisfied that this site still had technical and economic advantages compared with the others which had been considered. Nevertheless, it was the connection of such a line at Mop End thus making it a 400 kV switching station on the Supergrid which, appears to have led to objection by nearly all concerned.

The Board were commended by the Inspector for bringing before the inquiry the possibility of a future 400 kV line. So often in the past they had been criticised for not telling the public their future plans. If the suggested connection did come about; the necessary substation equipment and circuit-breakers could be installed in space that would otherwise be grassed over without in any way detracting from the lanscaping proposals. As for the need to meet the increasing demands for electricity in South Buckinghamshire and West Hertfordshire, the Inspector was satisfied that a new substation was needed, and that the transformer part of the proposed substation at Mop End would meet that need and provide for the future reinforcement of the zone in the best technical and most economic way.

The Inspector accepted the Board's argument that of the 53 acres required for the site a large part was to be used for ground modelling and landscaping, and the relatively small area required for the compounds would provide space for all the electrical equipment required by the local 132 kV system up to at least the year 1990. The Board did not think that any real purpose would be achieved by reducing the compound area merely to that required for four transformers; which would only meet the expected local demand for the 14 years up to 1985, after which time another site of similar acreage would be required for further reinforcement. Still less purpose would be served by having only a two transformer substation a Mop End because this would require another two sites. The proposal to provide space for eight transformers at the one site ensures the best use of land and electrical equipment, and provides for a greater security of supply; and it confines the possible damage to visual amenity.

The Inspector concluded his report by finding that the advantages of the Mop End site were that the overhead line modifications would have the least impact on amenity. The site would also be well screened not only by the existing woodlands but by the proposed additional landscaping from adjacent habitation and distant development of Amersham, Coleshill and the Missendens. Important factors were that it was in the centre of load growth and well located in relation to the position of the existing lines which crossed the Area of Outstanding Natural Beauty.

On the basis of this he expressed the following opinions:- (24)

"1. The proposal is one that constitutes very special circumstances, and as such the development can be considered within a Green Belt or Area of Outstanding Natural Beauty.

2. The technical and cost advantages of siting the substation close to the existing 275/400 kV and 132 kV lines at Mop End are abundant.

3. The appeal site is well chosen from an amenity point of view, and the installations are not likely to create a serious visual intrusion to the public except as regards users of footpath No. 27.

4. In Scotland hydro-electric schemes have become acceptable in areas of high landscape value, and personally I see no reason why a scheme such as this, so essential to modern living and progress, should not be acceptable if carefully sited and landscaped. So treated the substation might well form a point of interest to users of the footpath affected."

The Inspector accordingly recommended to the Minister of Housing and Local Government that the appeal be allowed.

The Ministry of Power Inspector in his report (25) on the Compulsory Purchase Order recommended to his Minister that he was convinced by the Board's case, and that the order should be confirmed.

The respective Ministers did not feel able to accept their Inspectors recommendations to approve the Mop End site, and after considering the matter for some five months wrote to the Generating Board in March 1968 (26) to ask the Board to carry out a further search outside the Chilterns Area of Outstanding Natural Beauty, and also if possible outside the proposed extension to the Metropolitan Green Belt, and to report accordingly.

9.5 Further Investigation of Alternative Sites

Following the request from the two Ministers the Generating Board prepared a report (27) examining four alternative sites. (28) Three of these were outside the A.O.N.B. at Longwick, Loudwater and Bulstrode Park, the latter being the most practicable one of those suggested by Amersham R.D.C. at the inquiry. The fourth site was the original site at Mop End.

The Board also laid considerable emphasis in its report that since the first inquiry they had completed a new design of substation structure which was significantly lower and less obtrusive. The earlier design of 400 kV substation is usually dominated by the heavy steel 72 ft. high gantries from which are suspended the insulators and aluminium tubes forming the connection for carrying current from one piece of electrical equipment to another. In the new design all this equipment would be superseded by self supporting aluminium lattice structures in the form of a bridge with a maximum hight of 54 ft. The new design of supporting structure also enabled the overall length of the substation to be reduced by about 100 ft. at each end. The difference between the Mark I and Mark II design is shown in photographs 36 and 37. (29) The Board also demonstrated the advantages of the Mark II design by preparing models of the two forms of electrical layout shown in photographs 59 to 62. In the Board's view this reduction in height and the lightness of the structure would be a considerable visual improvement, and constituted another reason why the substation at Mop End could be made visually acceptable. The Board concluded its report by reaffirming its justification for selecting the site at Mop End on both economic and menity grounds.

Copies of this report were sent by the Ministers to all interested parties and comments invited. Although such replies as they may have received were not publicised, it would be safe to surmise that they raised sufficient doubts in the Ministers mind to cause them to re-open the inquiry to give an opportunity for the additional evidence produced by the Board to be tested by cross-examination. The inquiry was accordingly re-opened on Thursday, 12th December, 1968 at Amersham Council Offices. (30)

9.6 The Inquiry Re-Opened

Two different inspectors conducted the second inquiry (31) and although they had avilable all the papers and a transcript of the evidence at the first hearing, the Board chose to present all the evidence a second time, which was further amplified by consideration of the three alternative sites put forward in their report.

The Board emphasised the fact that the reduced height of the Mark II substation structures partially eliminated any view of the substation at Mop End, other than from the footpath which would need to be diverted. All the evidence given by the Board's witnesses was directed to proving that despite its location in the A.O.N.B. it was the best site for economic, technical and amenity reasons.

The opposition to the Mop End site and tacit support for any alternative, was presented by Amersham Rural District Council and the local amenity societies, and was substantially the same as given at the first inquiry.

The local authorities of the alternative sites also appeared to object to the site in their respective areas and to discuss, cross-examine, and make representations upon the merits of the alternatives. The County Council, the Countryside Commission, and the Council for the Preservation of Rural England, supported the Mop End site as the "least offensive."

The Deputy County Planning Officer reading from his proof summed up with these words:- (32)

> ".....it seems to be quite clear that all the four sites would have an adverse effect upon local amenity to one degree or another, but in my view the crucial question concerns the lengths of additional overhead lines which would be required in each case. At each of the alternative sites, other than Mop End, the requirement is for a number of additional 400 kV and 132 kV lines radiating out from the substation whereas at Mop End, no new lines are necessary, and in the ultimate, a net addition of two towers will be the result. Having a regard to this and also to the fact that since the initial inquiry the Generating Board have designed a Mark II type substation which considerably cuts down the height of the necessary equipment, I am of the opinion that the site at Mop End would be least damaging to the amenity of this part of the country. In coming to this conclusion I have not taken into account the cost penalties calculated by the Central Electricity Generating Board for the three other sites relative to Mop End. In my view, on amenity grounds alone, Mop End is clearly the least detrimental of all the sites which have been put forward."

9.7 Conclusion

The Ministers have not yet issued their decision on this appeal, but by studying the evidence and the emotional attitudes of the various parties, one should be able to distil some general conclusions.

The Board made an attempt in 1961 (33) to anticipate the development of the 400 kV supergrid. Their plan was based on forecasts of the geographical patterns of load growth and of new generating capacity to supply that growth. Changes of detail were expected to arise in relation to the connections to new power stations and to new substations when precise locations were known. So far as is known and some seven years later no revised overall plan has been published. The existing 400 kV line at Mop End was foreshadowed in the 1961 report, but there was no indication at that time of the need for a possible substation. One is left with the impression that the Board although working within the framework of the 1961 plan nevertheless introduces some major schemes as and when the need arises.

The Board by not anticipating or announcing the possibility of this substation at the time of obtaining permission for the East Claydon to Iver 400 kV line, had in large measure made the selection of the Mop End site inevitable. If the requirement for a substation in South Buckinhamshire had been recognised in 1960 when the 400 kV route was being planned it would have presented the opportunity of routeing the line via a more acceptable substation site. On the other hand in 1960 the Chilterns Area of Outstanding Natural Beauty, had not been officially defined, but nevertheless the landscape beauty of that area is not confined to a Minister's confirmation of a line on a map.

The towns needing electrical reinforcement are still the same, so from the point of view of the Board it could be argued that nothing significantly had changed since 1960 to suggest that even if the possibility of a substation had been brought into the scheme of the overhead line the result would have been any different. The public however may have appreciated that this part of the supergrid had been considered comprehensively rather than giving the impression that their loss of the natural beauty of Mop End was an afterthought. The difficulty of adopting an objective attitude to the siting of a large substation in one's own locality is readily appreciated, but it is significant that the National Parks Commission with overall responsibility for the guardianship of National Parks and A.O.N.B's and the County Council with a county wide planning responsibility have both expressed a contrary view from that of the local authority.

An attempt has been made to form an objective assessment of the four practical alternatives and this has been set out in table No. 8. The assessment is made within the context of the electrical requirements as set out by the Board's system design engineer, and is not within the scope of this chapter to challenge these design parameters. On this basis it becomes clear that the site at Mop End is the obvious choice. The site at Mop End may be said to damage the principle of the A.O.N.B. but the adoption of any of the other sites would seem liable to result in a greater damage to the visual amenity of South Buckinghamshire.

Site	Effect of site on amenity		Mileage of new 132 kV connections on fresh routes. Overhead	Underground	Turn-in of existing East Claydon to Iver 400 kV line.	Turn-in of future Cowley to London 400 kV line.	Cost penalty compared with Mop End.
Loudwater	Partly within AONB. Outside Green Belt. Small impact on existing development.	In AONB	1.5	9.0	Turn-in would involve four additional miles of line, including 2 more in AONB and 1½ in Green Belt.	Impact on amenity so serious as to cast doubt on practicability of this site.	£ 570,000
		Outside AONB	1.0	9.5			
Bulstrode Park	Outside AONB. In Green Belt. Between A40 road and future motorway. No impact on housing. Worked out gravel pit.	In AONB	1.5	1.5	No difficulty. Passes very close to site.	Impact on amenity so serious as to cast doubt on practicability of this site.	£1,160,000
		Outside AONB	7.0	19.5			
Longwick	Outside AONB and Green Belt. Some impact on housing. Pleasant farmland of no special distinction. Visible at range of 2-3 miles from Chilterns Escarpment.	In AONB	2.0	28.5	7 additional miles of new 400 kV line required with considerable impact on countryside.	Practicable but over 4 miles of new 400 kV line required with considerable impact on existing development.	£2,490,000
		Outside AONB	2.5	12.0			
Mop End	In AONB, but well screened. Slight impact on existing housing at Mop End.	In AONB	-	15.5	No difficulty. Passes very close to site.	No difficulty. Would pass very close to site.	-
		Outside AONB	-	10.5			

TABLE NO. 8 Assessment of the factors relevant to four alternative locations for the selection of a substation site in South Buckinghamshire.

CHAPTER NINE

References

1. The choice of the Mop End site as a case study is also influenced by the fact that the writer had the opportunity of being present at both inquiries receiving copies of proofs of evidence, seeing a full transcript of the proceedings and the Inspectors reports as well as being fairly familiar with the locality. The complete list of documents referred to is given in the Bibliography for this chapter.

2. This area is shown dotted on map 50 and has been transcribed from diagram PJA1 which was exhibited at the public inquiry.

3. Map 48 shows how these electrical requirements are achieved and the geographical advantages of the Mop End site. Copies of this map were distributed at the public inquiry, as well as similar maps for the three alternative sites mentioned in the Board's report referred to later.

4. The Chilterns A.O.N.B. had been designated 26. 5.64 at about the same time as those preliminary site investigations were taking place.

5. Map 50 shows the location of these alternatives numbered 1 to 7.

6. This site is numbered 4A on Map 50.

7. This revised siting became the site the Board finally adopted for its Mop End proposal and is numbered 6 on Map 50.

8. Letter dated 21.1.67. The full text of this letter was read out at the public inquiry 22.8.67.

9. Letter dated 9. 2.67 read out in full at the public inquiry 22.8.67. It is noted that the view expressed is not that of the Commission, but one of its staff.

10. The public inquiry was held at Amersham R.D.C. offices from 22.8.67 to 25.8.67., followed by a further three days of site inspections.

11. Photograph 52 was one of the set of those exhibited at the inquiry with the site of the substation outlined on the photograph.

12. Photographs 53 to 58 lettered AA to FF are copies of those handed in at the inquiry. The view points are shown on drawing 1A included in the pocket at the end of this volume.

13. Two models of the electrical compounds were made, one of the standard form of electrical layout, and the other of the then new design which was considerably lower and generally considered to be a visual improvement. These could be inserted into the landscape model in order that comparisons could be made between the Mark I and Mark II electrical layouts.

14. Shown on Map 50.

15. These sites are shown on Map 50 and are numbered 8 to 13.

16. The following are on record as objecting:- Amersham Guild, Amersham Parish Council, Amersham Rural District Residents Association, Amersham Society, Beaconsfield Area Preservation Society, Chartridge Parish Residents Association, Chiltern Society, Coleshill Residents Association.

17. See Chapter 9 bibliography for list of press cuttings.

18. Report of Inspector to Minister of Housing and Local Government op. cit. Page 1. Paragraph 3.

19. The Chilterns A.O.N.B. had been designated 26. 5.64 but not confirmed until 16.12.65. The Board's outline application was dated 1.8.66 refused 2.3.67 and appeal lodged 13.4.67.

20. These sites were suggested by an Amersham R.D.C. Councillor who had walked some eighteen miles along the route of the existing 400 kV line. These sites are shown on Map 50 and numbered 8 to 13.

21. Ministry of Power dated 30.11.67 see Chapter 9 bibliography.

22. This dotted boundary is shown on Map 50 and has been transcribed from diagram PJA1 exhibited at the inquiry.

23. The Landscape Witness produced drawings GG2A and GG3A included in the pocket at the back of this volume to illustrate the extent to which the site may be seen, and his ground modelling and planting proposals to provide screening from the most vunerable viewpoints.

24. Report to Minister of Housing and Local Government op.cit. page 15 Paragraph 71.

25. Report dated 30.11.67. See Chapter 8 bibliography.

26. This letter dated 5. 3.68 was not made available to the public but was frequently referred to and quoted.

27. This report dated 17. 6.68 consisted of 18 pages as well as 18 maps and diagrams. It was frequently referred to at the subsequent re-opened inquiry, at which it seemed that everybody concerned possessed a copy.

28. These sites are shown on Map 50 included at the end of this chapter.

29. This illustration was included in the Board's report and copies were available to the public at the second inquiry.

30. The re-opened inquiry took place on 12, 13, 17, 18, 19 and 20th December, 1968 and the site inspections on 31st December, 1968 and 1, 2, 3, 7 and 8th January, 1969.

31. The first inquiry was conducted by Mr. French from the Ministry of Power and Mr. Harcourt from the Ministry of Housing and Local Government and the re-opened inquiry by Mr. Linton, Ministry of Power and Mr. Chown, Ministry of Housing and Local Covernment.

32. Proof of evidence of Mr. R.C. Kenyon. Page 8.

33. Statement on Development of the 400/275 kV Supergrid Transmission Network in England and Wales published by the C.E.G.B. in June, 1961.

Map 50 Alternative sites for a substation in South Bucks.


400 KV LINE TO EAST CLAYDON
N
14 + LONGWICK
5 + MANTLES FARM
2 + KINGSTREET LANE
3 + TOBY'S LANE
6 + MOP END
4 + ROUGH PARK
15 + SAUNDERTON
FEATHERBED LANE 1 +
7 + OWLSEARS WOOD
9 + LAYTER'S GREEN
10 + STAMPWELL FARM
8 + BULSTRODE PARK
11 + MOORHOUSE FARM
16 + LOUDWATER
12 + DUKE'S WOOD
13 + RUSH GREEN
132 KV LINE TO COWLEY SUBSTATION
BOUNDARY OF CHILTERNS A.O.N.B.
IVER SUBSTATION

PART FOUR: AMENITY ASPECTS

CHAPTER TEN

General Amenity Aspects of Overhead Line Transmission

10.1 Introduction

Aesthetics is properly a department of philosophy, but has become entangled in the electrical landscape. This study of the supergrid would be incomplete without considering the visual aspects of the towers and overhead lines, which are the most obvious part of the supergrid network; certainly from the point of view of the general public. One may have formed an opinion that transmission towers are beautiful structures striding grandly across the country, or exceeding ugly erections that demonstrate the inability of engineers to introduce aesthetics into their design calculations. The gentle curve of the conductors may give pleasure to some, but to others the sagging wires contribute to a wirescape that destroys any view in which they may be found. It is unlikely that this study of the factors influencing tower design would change these subjective opinions but it may lead to a better understanding and perhaps a little more tolerance towards the seemingly relentless "march of the pylons". (1)

10.2 Transmission Towers

The present supergrid galvanised steel lattice transmission tower, (2) is basically the same in design conception as the first 132kV tower of the original grid built in 1928. Three years previously the Central Electricity Board had invited three approved overhead line contractors to submit a design with an estimate of cost to meet certain electrical requirements specified by the Board. The Board even at that time were concerned about the general appearance of the towers and their effect upon the landscape. From an engineering and cost point of view one design of tower was stated to be clearly superior to the other two, but before the final selection, scale models were made and shown to a panel of eminent architects. (3) The Board also consulted Sir Reginald Blomfield R.A. and the design of the towers was finally settled following discussions with him.(4)

Early in 1950 preliminary design work was carried out for the proposed 275kV towers, and these were similarly developed as the result of three competitive tenders. (5) Scale models of each design were prepared and submitted to the Authority's consulting Architectural Advisors, who selected the one they considered was most acceptable aesthetically. (6) This was subsequently adopted as the Boards standard tower design. Since then further design and development has taken place. The use of aluminium alloys for the top sections of towers, as well as tubular members for tower cross-bracings had been investigated by the B.E.A. between 1950 and 1953 which would have effected a considerable saving in the weight of steel required,(7) although probably more expensive. This development does not seem to have been pursued. A prototype 275kV tower constructed of prefabricated welded tubular steel frames had been developed, and apparently tested successfully in 1957, but nothing further has been seen or heard of this new tower design(8).

In 1960, competitive designs were invited from the four main overhead line contractors which were based on the earlier steel lattice construction used for the 275kV and 132kV towers. The differences between the four submitted designs are mainly in the pattern of the bracing, which is not readily distinguishable and does not affect the overall shape or height of the tower. (9)

Drawing 1 included in Chapter 6 shows the outline of the Boards standard height double circuit suspension towers of 132kV, 275kV and 400kV. They range in height from 86 ft. to 164 ft. It must be emphasised that these are standard height towers and that the tower construction has been designed to readily accommodate extensions in increments of 10 ft. to a maximum of five. The highest type of standard designed tower would therefore be about 214 ft. It is not always appreciated that the use of extensions is fairly frequently required to ensure a safe distance between the conductors and the ground or objects, and the average height of a line of towers is usually considerably more than the standard height for the appropriate voltage.

There is considerable divergence of opinion whether the present design of transmission tower is visually the best that can be designed. The Board quickly answers critics by saying that they seek to ensure that the design of the tower structures is the most graceful that can be devised. (10) and that well known and distinguished British architects were consulted and had approved the design and that the recent designs for 275 and 400kV towers had been submitted and approved by the Royal Fine Arts Commission. (11) So far as the Board is concerned this appears to be the final answer, nevertheless from time to time the question is raised in correspondence in the national papers and sometimes in parliamentary questions. A few years ago the Minister of Power was asked what study had been made of the design of electricity pylons to make them as inoffensive as possible to the amenities of rural areas (12). This question was raised again in 1964 and 1967, and in every case the stock reply was given (13).

The official parliamentary reply does not necessarily indicate that the Board is not concerned about this matter, nor that its engineers are no longer considering the question of tower design. The standard Boards towers dominate the tallest trees and are usually completely out of scale with the

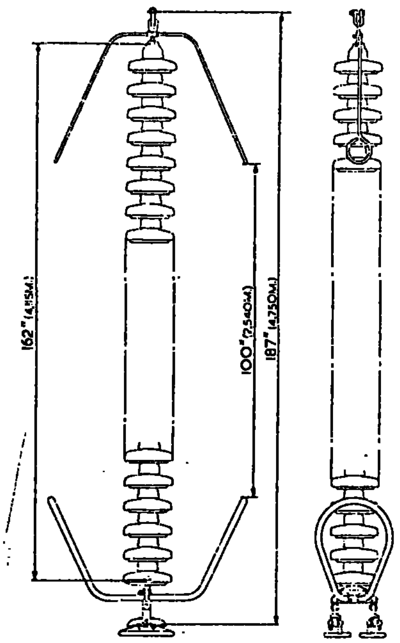
English countryside. A substantial amenity improvement would be made if the height of towers could be substantially reduced. With this principal objective the Board have evolved a design for the structural cross arms of a tower that supports the live conductors to be made of an insulating material. An experimental line has been built at Connah's Quay in Lancashire for tests. This development it is hoped would reduce the height of a standard 132kV tower from 89 ft. to about 75 ft., and if succesful be subsequently applied to the higher supergrid voltages. (14)

The Board frequently has its attention drawn to the many examples of transmission towers erected in other countries with the comment that they are always so much more elegant than those constructed in Britain. These criticisms are sometimes valid but on closer examination it becomes apparent that the comparisons are not being made between similar voltages, nor the carrying capacity of the line, or the terrain through which the line is routed. Although one hears more from the critics of the Boards tower designs than from those that find them tolerable, nevertheless from a close study of many Continental and American examples the Boards steel lattice transmission towers are generally regarded to be an uninspired but workmanlike solution to a complicated engineering and aesthetic problem.

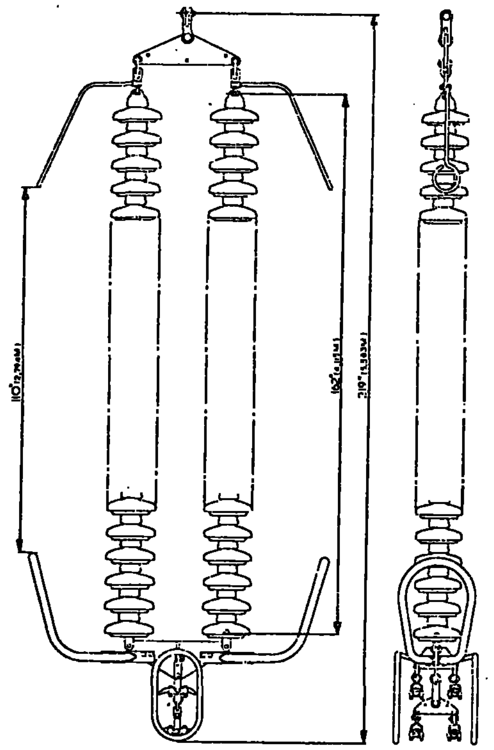
10.3 Overhead Line Insulators

An overhead line conductor carrying electricity is insulated from the ground by the intervening air, but it must also be supported by some means that prevents electrical continuity with the structure that carries it. It is not proposed to discuss the shape of an insulator as this is largely determined by the electrical requirement to provide the minimum distance between metal consistent with safety, and the practical requirement that the insulator should be self cleansing by rain in order to prevent an accumulation of dust that would reduce its effectiveness. Drawing 5 shows the insulators

Suspension Sets



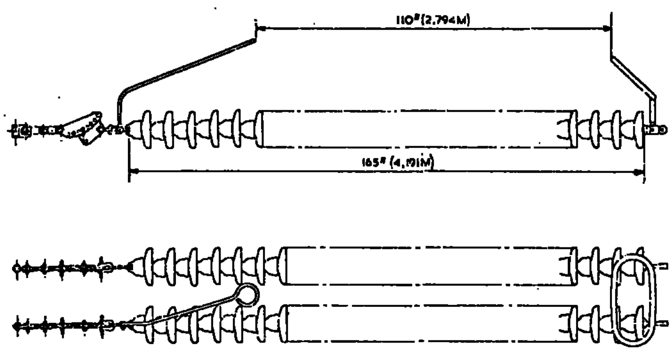
400 kV (twin)



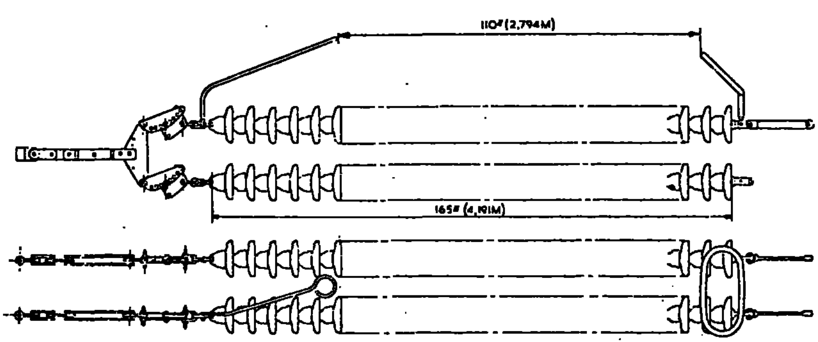
400 kV (quad)

Tension Sets

400 kV (twin)



400 kV (quad)



Drawing 5. Tension and suspension insulators for 400kV lines.

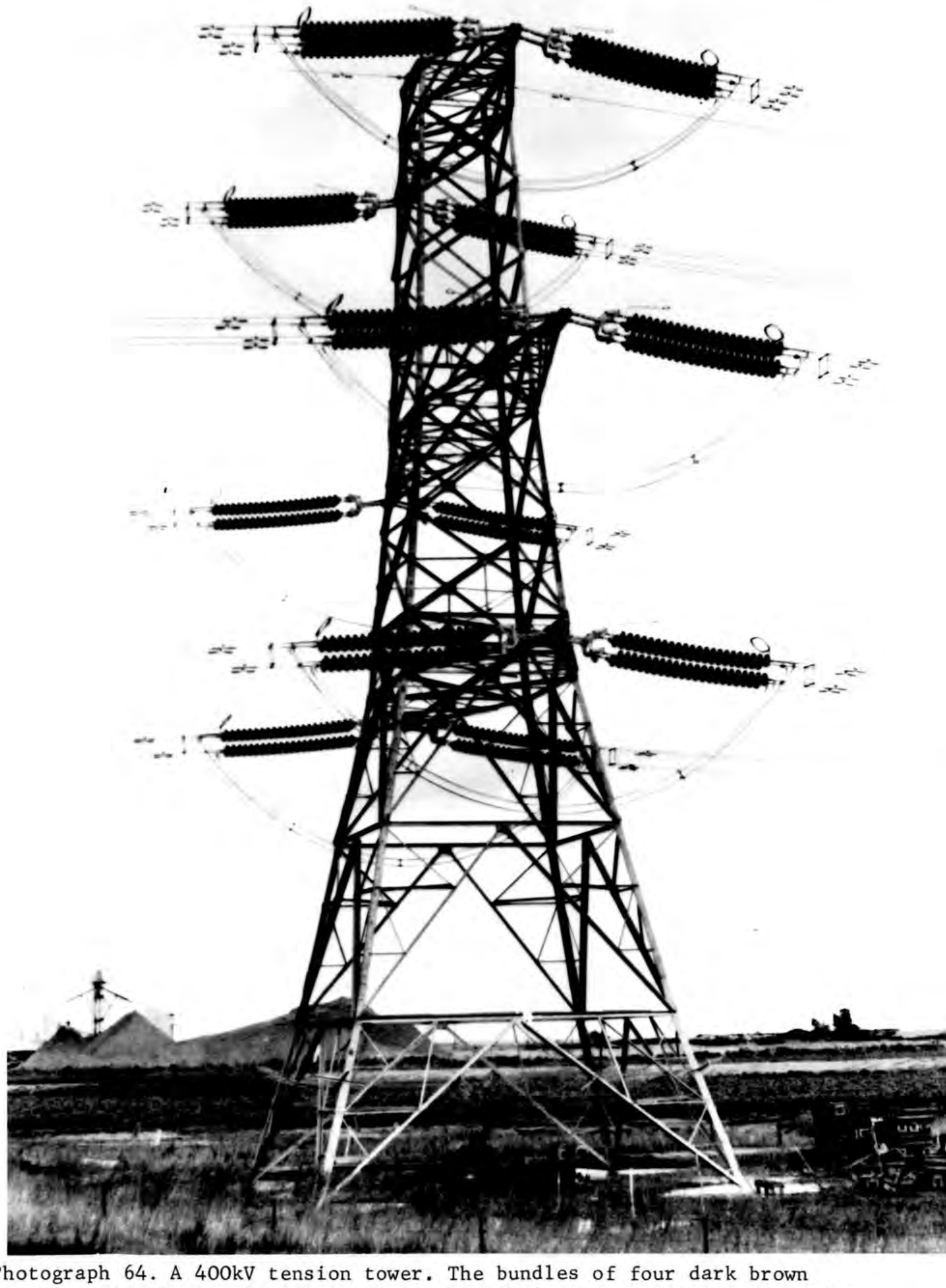
required to support 400kV twin and quadruple conductors. It will be noticed that there are two different types. There is the vertical arrangement of suspension insulator sets when the conductor is hung from the bottom of the insulator, and the horizontal arrangement when the string of insulators is in tension to resist the pull of the conductor. The twin 400kV conductor is carried by one suspension set, and two tension sets of insulators, and the quadruple bundle of conductors require two strings for suspension and four strings in tension. The visual effect of these arrangements are shown in photographs 63 and 64.

Insulators are manufactured from either porcelain or toughened glass. It has been observed that generally the whole length of a line has been fitted with one type. There are a few instances when both types have been used on a line, but the change of insulators on adjoining towers a quarter of a mile apart is not visually disturbing. No instance has been seen when both porcelain and glass insulators have been fitted to the same tower, and in such a case as this one may imagine that the visual result would be most disturbing.

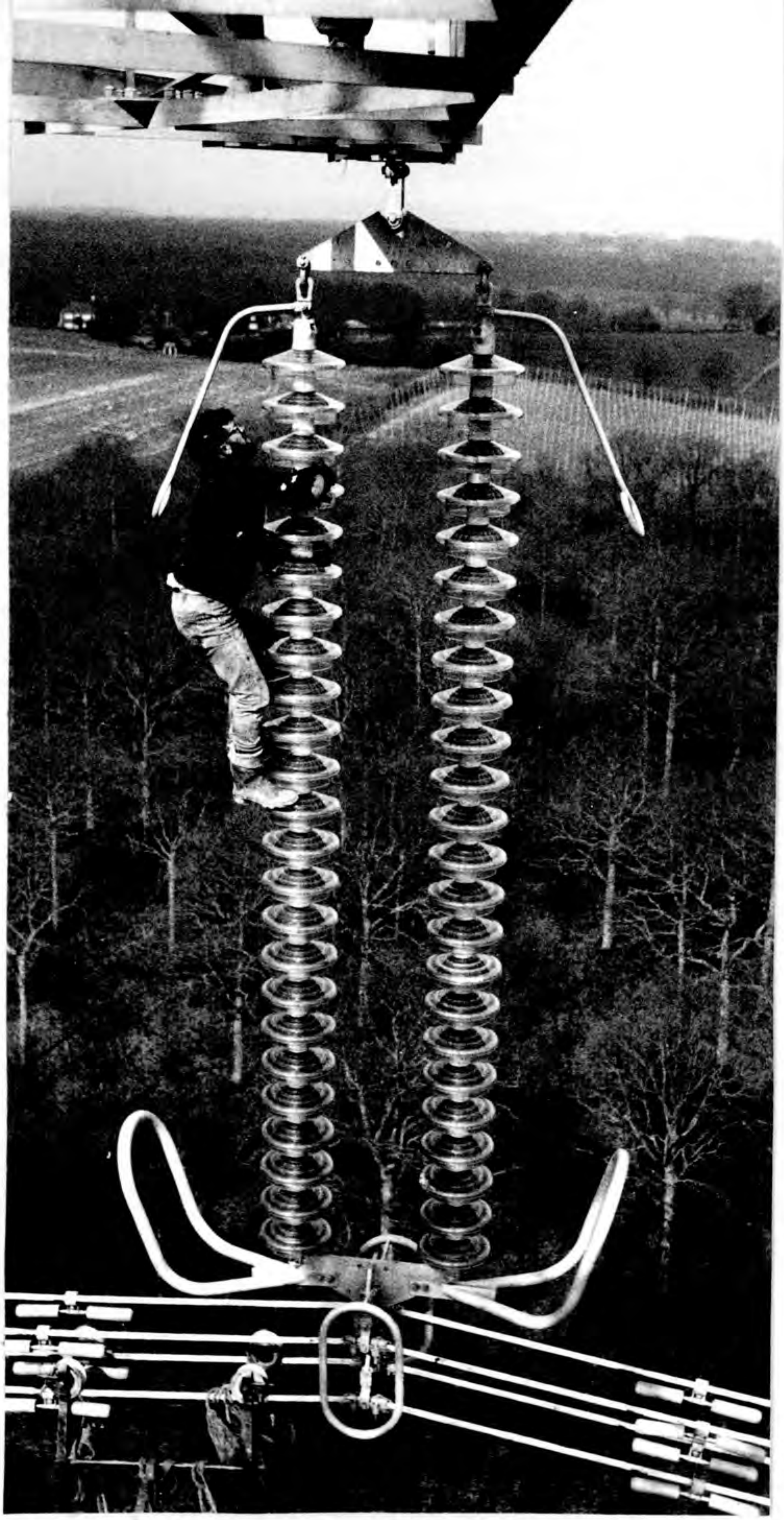
So far as is known the Board has not promulgated any amenity policy on this question of insulators. It seems to the observer that either porcelain or glass insulators may appear in any situation. It is thought that the Boards requirements for insulators is greater than the present manufacturing capacity for either type, and that the Board is unwilling to concentrate on porcelain or glass for fear of creating a monopoly situation as only one porcelain, and one glass manufacturer produce these insulators.

Both types are susceptable to damage, the porcelain merely chips or fractures, the glass on the other hand when hit by a stone, or a pellet from a powerful air rifle shatters into a spectacular shower of small cubes of glass. It has been noted that when this display has first been achieved

Photograph 63. A 400kV suspension tower showing two strings of porcelain insulators to carry a bundle of four conductors.



Photograph 64. A 400kV tension tower. The bundles of four dark brown porcelain insulators become a strong visual element detracting from the current line and light construction of the lattice tower.



Photograph 65. A suspension string of glass insulators on a 400kV line. The trolley with which the linesman inspects the conductors and insulators is just visible in the bottom left hand side of the photograph.

Photograph 66. A tension string of four, 400kV glass insulators, at the Gloucester end of the line to Ystradgynlais substation in South Wales.

on a section of line, it is quickly followed by many more broken insulators. It is more for this reason than any other that the Board tends to prefer porcelain.

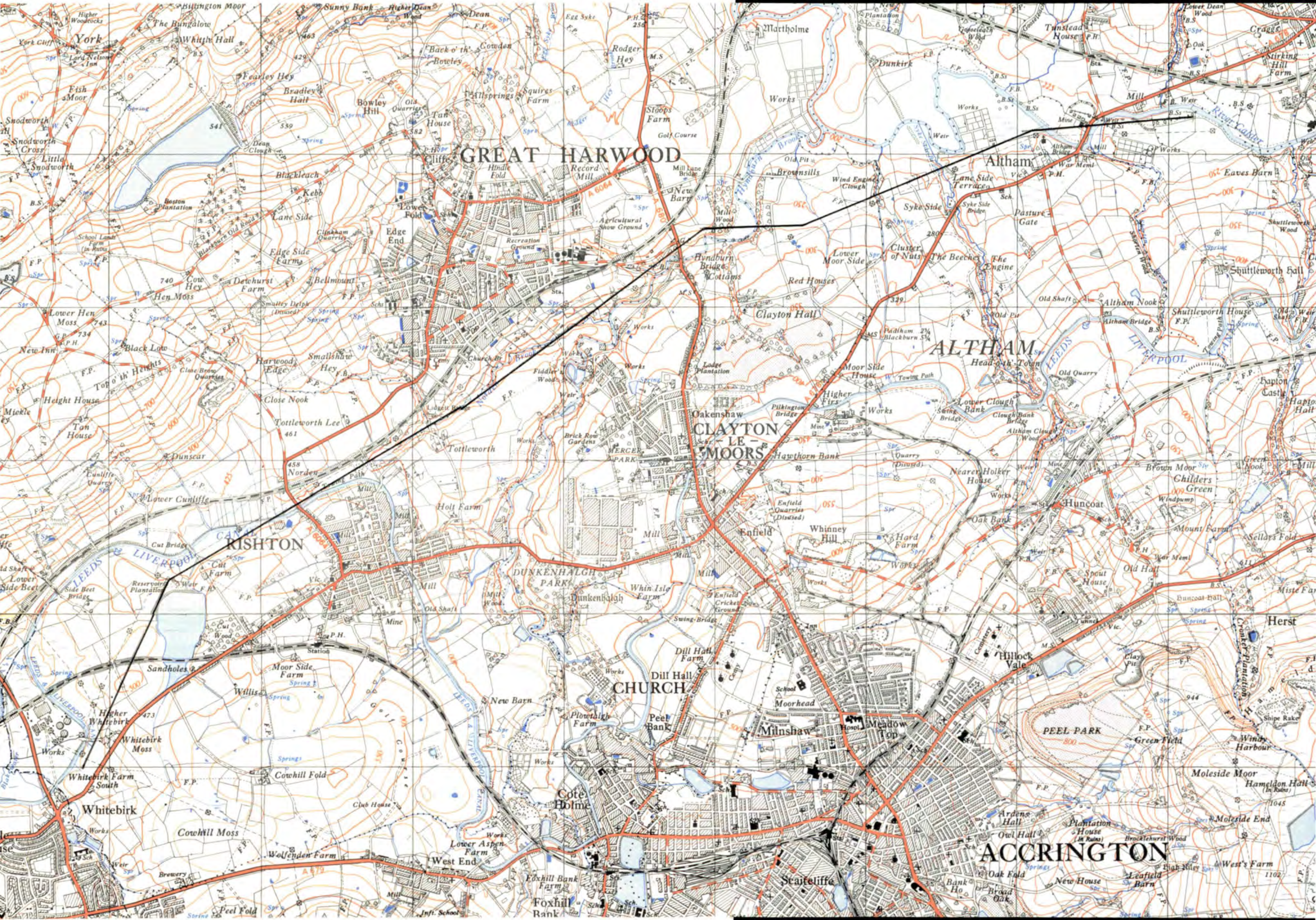
Twelve strings of dark brown insulators, each string over 13 ft. long suspended from a 400kV supergrid tower, becomes quite a significant visual element in an overhead line route. It is not known whether it is due to public criticism, but the Board has recently been experimenting with colours other than brown for porcelain insulators. Apparently green, white, and dull yellow colours are feasible, but the Board has said that they are more difficult to make and would therefore cost more. (15) However the Board as on experiment is proposing to fit light grey insulators on a 7 mile section of the 400kV line that is about to be constructed between Bradford and Darwen, (16) shown on map 53. It will be interesting to see whether this experiment brings any public response.

Another way of reducing the visual effect of insulators is to reduce their bulk, either in number or size. Research has been proceeding with this objective, and the Board has recently announced (17) that improved design and manufacture of both toughened glass and porcelain insulators has enabled a single string of insulators to be used instead of the double string on suspension towers, and the use of two strings instead of four strings on tension towers.

One may optimistically hope that further developments in glass and porcelain technology, with the added effect of colouring may eliminate entirely one of the minor but nevertheless significant usually discordant elements of an overhead line.

10.4 Colours of Transmission Towers

In any thorough investigation of the visual effects of transmission lines the question of the colour of transmission towers must be considered.



Map. 51. Route of the 400kV line from Whitebirk to Altham for which the Board proposes to use coloured insulators as an experiment to see if they offer any amenity improvement.

The Board is frequently asked to paint the towers in order to make them less obtrusive. Such requests often originate either from landowners faced with the prospects of having towers erected on their land, (18) or from local authorities, (19) and amenity societies when they are considering the effect that an existing or proposed overhead line will have in their area. The most frequent suggestion is to paint the towers green. The argument advanced is simply that as trees, shrubs and grass are generally green, a green object in such a situation would be indistinguishable. A typical request was made by some residents at Aldridge near Birmingham affected by a tower route who wrote to the Minister of Power urging him to have the "pylons painted to match the green belt". (20) It would seem justified to examine carefully why these requests arise, and any action the Board has taken to consider them. It is known that at least three tower painting experiments have been carried out by the Board in Hertfordshire, Monmouthshire, and Lancashire.

The first occurred sometime at the end of 1959 on four 85 foot high towers on the 132kV line between Oxford and Watford in the neighbourhood of Rickmansworth and Chenies. (21) The towers were carefully chosen for their differing backgrounds against woods and hillsides, scrub and arable land. Painting was completed in March, 1960, and the results were subsequently studied in both winter and summer settings. A different colour scheme was tried on each tower. One was an all-over painting in dark bronze green. Another was painted similarly for the first 40 feet of its height with the remainder of the tower treated in irregular patches of pink and blue. A third was painted in all-over irregular patterns of black, bronze green and pink, and the fourth black and green at the bottom with light blue and pink above. A matt paint was used throughout to avoid light reflection.

Both Sir Christopher Hinton, Chairman of the Generating Board, and Sir Willian Holford, a part-time Member of the Board studied the results.(22)

It would seem that the major disadvantage, particularly in the case of the towers which had been painted with a disruptive pattern, was that the changing conditions of light and weather made ineffective any attempt at all-out camouflage. A tower which was lost to view on an overcast day or beneath broken clouds was said to show up most markedly under a strong sun, and that the changing seasonal colours of the background had an equally important effect. The tower painted black and green at the bottom with light blue and pink above to merge with the sky, was reported to be almost invisible from half a mile away in one direction but was conspicuous from another. A similar treatment for another tower, which stood out if viewed against the light background of the trees nearby, was stated to be a perfect match with the dark woods when the viewpoint was changed by a quarter of a mile.

Sir Christopher Hinton made a reference to this tower painting experiment in November 1959 when he addressed the Royal Society of Arts on the subject of the electricity supply industry and visual amenity. (23) He was of the opinion that the uncoloured steel lattice tower with the matt finish of weathered galvanising was the least conspicous of all possible outlines when seen against sky or hill. He said that this was particularly so when compared with concrete towers, even though these might be cheaper to produce. When painting becomes necessary, his own preference coincided with that of the Council for the Preservation of Rural England and others, which was for a light or medium grey or grey-green, depending on the type of country through which the line runs. He thought that apple green, light blue and white, which had all been tried, may have looked right in a few situations, but not in this country with its ever-changing seasonal variations of natural colour.

The second tower painting exercise took place in South Wales where it has been observed that a few towers in the Severn Valley near to Whitson had been painted a silver grey colour, which distinguished them from the usual dark grey colours of the adjoining towers. It was noticeable even on dull and overcast days that the silver grey towers stood out from the surrounding landscape, and they appeared particularly conspicuous in sunlight.

Another experimental painting had been carried out in the area of the Wirral Peninsular where several miles of 132kV towers had been painted a light blue-green colour. From a personal study of these towers one may conclude that in a very few cases, and for a short time when seen against a blue sky they appeared inconspicuous, but for the majority of towers their rather 'pretty' colour tended th attract attention.

If it is intended that an object should be painted to make it as inconspicuous as possible, a general principle seems to be that a colour should be selected to match the tone of the background of the object as seen from the principal viewpoint, and blue greys would mainly be used for objects seen against the sea or skyline. Dark colours will appear as shadows in poor lighting conditions, and for objects at or near ground level, black is often the most appropriate choice. The green colours seen in nature are muted tones of infinite variety, broken up by the form and texture of plants, and modified by light and shade, time of day, season and distance. Painted surfaces are not affected in the same way and so remain hard and flat, and therefore, seldom appears 'natural'.

To apply these general principles to the question of tower camouflage, and from observation of the experimental paintings the conclusion to which one may come is that to achieve even partial success, the Board would have to treat each individual tower as a special subject. Even then the constantly changing and infinite number of viewpoints from which towers may be seen would further complicate the problem. It also seems that the benefits to be obtained from the only practical forms of camouflage are, in fact, marginal due to the varying conditions of light, viewpoint and seasonal background.

The Royal Fine Arts Commission have also been consulted on this question, and they were of the opinion that it would be a mistake to lay down any form of rule for the colour of towers as this should depend on the type of country through which the line was to run.

The Council for the Preservation of Rural England have also from time to time shown an interest in this problem. (24) Mr. Peter Shepheard a Landscape Architect of considerable experience in these matters reported to the Executive Committee of the C.P.R.E. that he was firmly of the opinion that the best colours for merging with the countryside are very dark and neutral ones, and his own choice would be bronze green, British Standard Colour 4-051, or dark grey. However, he qualified this by adding that in certain conditions even that might prove to be too dark.

The colouring of transmission towers was also raised in the House of Commons in 1965 (25) when the Minister of Power was asked what experiments had been carried out into the camouflaging of electricity pylons with a view to lessening their adverse effect upon the beauty of the countryside; and if he would make a statement on his conclusions that were so far available to him.

The Parliamentary Secretary in replying said:-

> "Experiments with camouflage painting in 1960 led to the conclusion that, for the majority of conditions, the natural grey of weathered galvanised steel rendered towers least noticeable."

Following a further question he added:-

> "Various colours and combinations of colours were tried, but in the changing conditions none was successful in merging towers into their backgrounds. The Council for the Preservation

of Rural England reached the same conclusion as the Central Electricity Generating Board - that weathered grey or galvanised steel were the best to use."

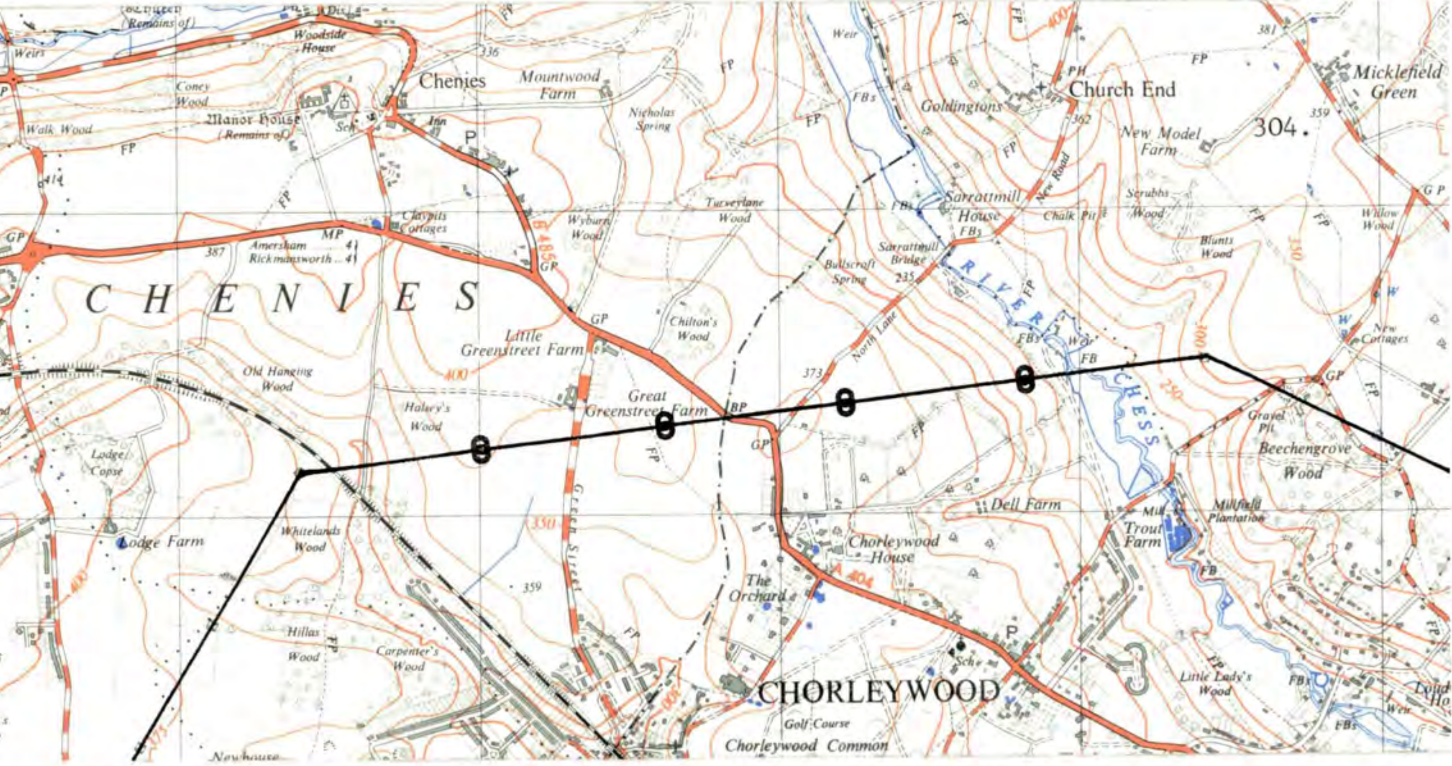
It has been suggested (26) that the aluminium colour normally used is believed to have been chosen by the Board partly on safety grounds, because it makes the towers visible to aircraft. It is not thought that there is much validity in this suggestion as the bright aluminium colour of recently erected towers is the effect of newly galvanised steel which soon weathers to a dull grey.

More recently at the request of the Local Authority the Board has expressed its willingness to paint about 20 towers where the line crosses the famous beauty spot of Barr Beacon Staffordshire in an attempt to make them less conspicuous. The Board's Architect recommended that the towers should be left unpainted as he did not think that painting them would improve their appearance or reduce their visibility. However, if the Local Authority insisted that the towers should be painted he suggested blue-grey as "this had some affinity with the sky background. (27)

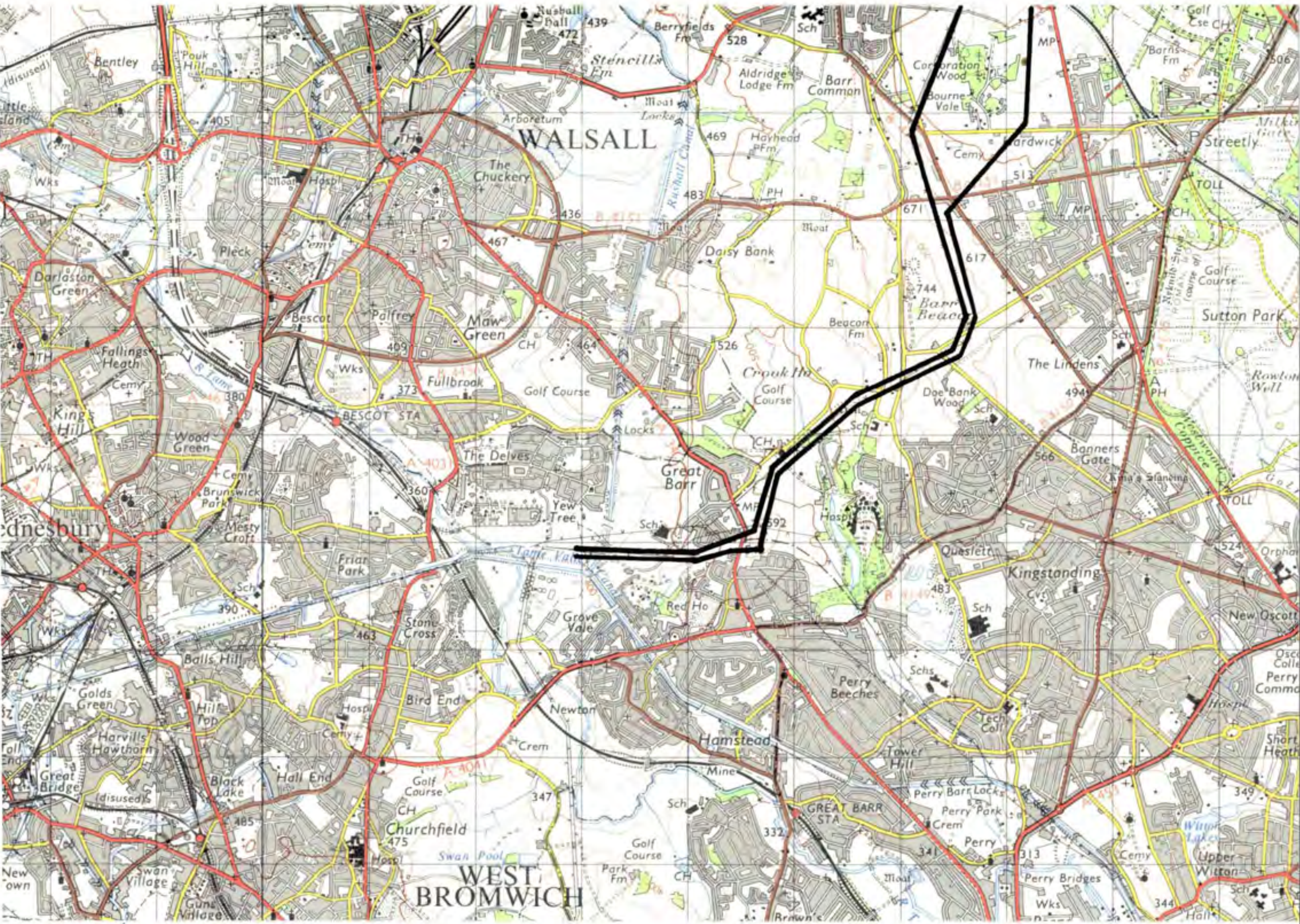
The concensus of informed opinion would seem to be to leave towers in their natural steel-grey colour and, when repainting becomes necessary, to use the British Standard dark bronze green No. 4.051 or a dark grey British Standard colour No. 9.097, as recommended by the Council for the Preservation of Rural England. (28)

From these experiments it appears that the Board's general policy for the painting of towers in camouflage colours is to do nothing. The effect of the weathered galvanised steel would seem to be considered the most satisfactory for the majority of conditions, and any incidental rusting merely improves the camouflage.

Repainting is however, necessary from time to time, which always seems to be done in dark grey, but one would wish that a little more



Map 52. Location of towers at Chenies in Hertfordshire used for camouflage experiment.



Map 53. The Drakelow - Bustleholm 400kV Quad .4 line lies to the west of, and is routed parallel to the Drakelow - Hams Hall 275kV Twin .4 line. Camouflage painting of towers is proposed for that part of these lines that cross the high ground at Barr Beacon, Staffordshire.

Bronze Green British Standard Colour No. 4.051

Dark Grey British Standard Colour No. 9.097

These sample colours, are the colours recommended by the Council for the Preservation of Rural England for the painting of transmission towers, and which has now been adopted by the C.E.G.B.

sensitivity could be shown by those responsible for arranging this work, so that minor changes in colour could be made to take account of the individual situation of each tower. The public would thus be made aware that the Board is concerned with such matters, rather than leaving the impression that it conducts a few small experiments, as a result of the pressure of public opinion, in order to justify its action of repainting every tower in England and Wales the same colour.

10.5 Conclusion

The erection of any prominent structure is not simply a case for the expression of personal taste but a public matter; the designer owes a definite duty to the public which he must attempt to discharge. Most problems involving structures allow of alternative designs, all being equally suitable with regard to strength and stability, for achieving the stated object.

A structure which is aesthetically satisfying is not necessarily more costly than one which is not, but the design often makes greater demands upon thought and skill. In a country such as Great Britain so many developments make a more or less permanent alteration to the skyline that the Board should be seen to give the design of its transmission towers the greatest consideration.

The Board however has chosen to adopt the somewhat unusual method of inviting tower designs from overhead line contractors. This procedure in the normal manner of competitive tendering would tend to emphasise the aspect of lowest cost rather than the aesthetics of the resultant design. The fact that these designs are subsequently approved by distinguished architects and the Royal Fine Arts Commission may seem to imply that the Board wishes to acquire an insurance against possible criticism rather than a genuine desire to produce the most visually satisfying design.

A particular solution will generally fit only one case, requiring qualities of judgement and discrimination on the part of the designer as well as the ability to accurately asses the individual circumstances and an adequate knowledge of structural design. Inspiration must play its part, as most forms or shapes of aesthetic value result from the inspired conception of one individual.

The view is generally held that aesthetic considerations are inherent in the fundamental design of a project and cannot be delegated without delegating the whole of the design. In the case of the Boards work this rests primarily with engineers either to neglect or to cultivate this aspect, which is fundamentally their responsibility.

It is possible that a better tower design may have resulted if the original brief had been given to an eminent architect and or structural engineer, and then the overhead line contractors be invited to tender for the construction. The final test in any instance, however, must be the acceptability or otherwise of the resultant design to the public.

CHAPTER TEN

References

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2. 'Galvanised steel lattice transmission tower' is the correct and full description referred to simply as transmission towers. Occasionally one still hears them referred to as 'pylons' but despite considerable research it has not been possible to discover when this word was first used nor how it gained currency. The Board so far as one has been able to discover has never used the word pylon in any of its technical publications, although it occasionally appears in the 'house magazine' type of publication.

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At this time the Architect Advisers to the British Electricity Authority were:- Professor W.G. Holford, M.A.,M.T.P.I.,F.R.I.B.A.
Mr. A. Graham Henderson, A.R.S.A.,F.R.I.B.A., and
Sir Percy Thomas O.B.E.,M.T.P.I.,F.R.I.B.A.
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Bryant Godman Irwine.

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19. Torquay Borough Council, Torquay Times, 14.1.66. Burnley R.D.C., Burnley Evening Star, 27.8.66. Selsdon R.D.C., Wolverhampton Express and Star, 22.10.66. Suggestion made by Mr. Samuel Parry at the North Wales Branch of the Rural District Councils Associations. Chester Chronicle, 15.3.68.

20. Birmingham Evening Mail, 26.8.66.

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22. The Board appointed as a consultant to advise them on this experiment Mr. James Gardner, an industrial designer who was formerly the Chief Development Officer of the Army School of Camouflage during the last war.

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24. Council for the Preservation of Rural England Annual Report 1958-59, Vol. XVII. No. 1 page 19.

25. House of Commons Hansard, 13th July, 1965. The question was asked by the Earl of Dalkeith and answered by Mr. John Morris the Parliamentary Secretary to the Minister of Power.

26. C.P.R.E. Annual Report Op.cit. In 1950 the British Electricity Authority were concerned about the corrosion of tower steelwork and as an anti-corrosive measure some towers were sprayed with aluminium. This made the towers very conspicuous and it was possibly these towers to which the C.P.R.E. were referring. B.E.A. Annual Report 1951 page 28 para. 117.

27. Birmingham Post 30.11.68. The Guardian 2.12.68. Daily Express 2.12.68.

28. C.P.R.E. Annual Report Op.cit.

CHAPTER ELEVEN

Landscaping

11.1 Introduction

The word landscaping is used in the generally accepted sense by Landscape Architects to express the function of creating landscape. Landscape as created by man in the context of the Generating Board's operations means earth moving to create artificial ground shaping, and grass seeding with tree and shrub planting. This activity done solely for the purpose of protecting or improving the visual amenity of a locality has a direct effect on land use. This chapter examines why the Board carry out landscaping, their policy towards this activity, and a critical assessment of what has been done.

11.2 Obligation of the Board to Carry Out Landscaping

One might reasonably ask, why should the Board concern itself with landscaping? It does so for two main reasons:-

The first is a statutory duty laid upon the Board by the provisions of the Electricity Act 1957, and also the Countryside Act 1968. In the case of the Electricity Act, Section 37 requires the Board;

> "In formulating or considering any proposals relating to the functions of the Generating Board............ shall take into account any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, buildings or objects". (1)

The marginal note to this section in the Act refers to "Preservation of Amenity". This section is known generally as the "Amenity Clause". The more recent Countryside Act extends the preservation of amenity required to all public bodies. (2) In this statute the marginal note refers to 'Conservation of Natural Beauty' which perhaps makes a slight distinction between preservation and conservation; but in the case of Electricity Supply Industry the more recent Act merely reinforces the former obligation.

The second reason for the Board carrying out landscaping schemes is because the Board is required to obtain planning permission for its works, and in the majority of cases the Local Planning Authority imposes a landscaping condition upon the grant of consent.

One might well question whether the Board would carry out landscaping for the first reason, if Planning Authorities did not insist upon it, and it is a debatable point whether the Board would be justified in carrying out more extensive landscaping than the Planning Authority required, or to carry out any in those few cases when the Planning Authority has not imposed a landscaping condition. It is estimated that about 90% of all primary grid substations have a planning permission requiring them to be landscaped, and it is now proposed to consider what is the Board's attitude towards this obligation.

11.3 <u>Board Policy on Landscaping</u>

The Board frequently reiterates its concern for amenity and mentions the apparent conflict between the dual statutory requirements of providing an economic supply of electricity and the need to pay regard to amenity. The Board rarely refers to the contribution that the Landscape Architect can make to resolve this conflict, and to the improvement of the visual effect of its buildings and structures.

In the C.E.G.B. 1961 Annual Report (3) the Board did have some comments that may fairly be regarded as a statement of their general policy. The Board, it said were continuing their efforts to preserve amenity; and their concern found practical expression in personal inspections by Board Members of actual or prospective construction sites and transmission routes, and in discussions of amenity problems with interested parties, including learned and scientific bodies.

The Board sought to promote the highest standards of architectural and landscaping skill, but despite this the reaction against their development proposals had sometimes been as severe in industrial and semi-urban areas as in the more highly prized areas of scenic or scientific interest. The Board's architects and amenity advisers offer early, continuous and informed advice on the siting and design of proposed development and on the visual elements both internal and external which comprise it. Close co-operation has been established between architect and engineer in determining the shape and relationships of buildings and plant and the general site layout; to achieve an overall treatment of the site and its development as part of the surrounding countryside within a single coherent scheme. The report goes on to say that with sustained aesthetic effort from the begining of the designs until the landscape architect finishes his contribution to the completion of the station and its surroundings, the Board hoped to ensure that the modern power stations in England and Wales would not suffer in comparison with those of any other undertaking or country. Although transmission lines and substations are not specifically mentioned it may reasonably be assumed that the same Board policy would apply.

The Board's Chief Wayleave Officer recently said as much in a glossy publicity booklet when he wrote:- (4)

> "The substations of the Grid system range from 132 kV plant on perhaps half an acre of land to the great 400 kV transforming and switching stations occupying, with landscaping 30 to 40 acres. Architectural treatment at such substations is of necessity confined to the design of structures and buildings and to the use of colour where this can be helpful. Careful choice of site is, however, all important and this is followed where necessary by landscaping, embracing the creation of earthworks and tree planting which may, with the co-operation of adjoining owners be off site. Such work has already taken place at many substation sites but the full effect is not yet apparent. There is little doubt, however, that in a few years there will be abundant evidence that the care taken has been rewarded."

He went on to say that so far as landscaping was concerned, in common with other industrial undertaking, but on a vaster scale, the Generating Board have become the modern patron of the landscaping art. The great landowners of the eighteenth century employed the founders of the profession, William Kent, Capability Brown, Humphrey Repton and their followers. Today, the Generating Board engage practising landscape architects of the first rank and a new philosophy of landscape design is emerging, often experimental, sometimes inspired but always seeking a solution to complex problems.

These rather poetical words should be received critically, but by 1966 some of the first results of landscaping began to be seen, and it might seem that the Generating Board members themselves began to appreciate the beneficial results of careful and skilled landscaping, at the same time as an increasing public awareness. Mr. Booth the Board Member for engineering showed that he at least possessed an appreciation of what the Board's landscape architects had been doing in the field of primary transmission.

He said, in a paper that he read to the Institute of Electrical Engineers, (5) that in his opinion, which he believed was shared by some people who were not engineers, that substation structures had their own aesthetic appeal. Furthermore, he was now seeing the results of the care taken in recent years to improve the 'trim' of substations - in the design of buildings, surfaces, access roads, fencing and so on. Nevertheless, in beautiful country, with no other sign of industry, the visual combination of substation and terminal towers was still a real problem in visual amenity. He considered that the careful choice of the site was all important, and in this the C.E.G.B. are largely dependent on the wishes of the planning authority. He went on to say that considerable landscape work was also being done to improve the appearance of sites not naturally well screened. A detailed survey is made of all existing trees and hedges on every new substation site, and all those worth keeping are moved to new positions before the main construction work starts. Landscaping schemes may involve considerable earthmoving operations for ground modelling, as well as extensive tree and shrub planting, and offsite screen planting is sometimes done with the agreement and co-operation of the landowner. The Board has used the latest techniques for moving and planting large trees to help create a new but mature landscape. The landscape architect worked as part of a team with electrical and civil engineers in the planning and construction of substations, and his special responsibility was to advise on the overall visual effect. He also mentioned that the C.E.G.B. had a staff of landscape architects to undertake this work.

Mr. Booth in his paper went onto say:-

> "By far the best way to make a substation look well in a landscape is to choose the right place in the landscape. If that can be done, much less money and agricultural land are needed for landscaping. Next time you visit one of the C.E.G.B.'s recently commissioned substations I hope you will observe the fruits of these efforts. Imagination will, of course, be necessary to see what the landscape architect is driving at - when the trees and shrubs have grown up. To take just one example: Enderby, a 400 kV substation near Leicester is very well sited, and the substation structures themselves, the carefull designed buildings, surfaces and fencing, all related to each other in colour and texture, plus some 'mounding' and some modest and judicious planting of trees, form a whole which is a credit to the C.E.G.B. and to the country from the aesthetic, as well as the technical, point of view."

This then, so far as one can discover are the only official statements on the landscaping of the Boards electricity substations.

Although these two statements indicate that the Board is concerned with landscaping, they appear rather in the guise of good public relations and seem to express what they think the public wants to hear rather than the Board really feels. It is unlikely however that the Board would declare itself against the need for landscaping, but its lack of sustained comment on this aspect of its responsibilities might incline one to think that it is something that the Engineers of the Board would prefer to relagate to a minor and insignificant role. If the indications are that the Boards senior Engineers are more concerned with engineering than amenity it may be worthwhile to examine how the Landscape Architects engaged upon this work see the problem in visual terms, and their design philosophy for solving it.

11.4 The Board's landscaping design philosophy

The engineering of all the primary grid substations in England and Wales is carried out by a Transmission Project Group of the Generating Board whose offices are at Guildford in Surrey. (6)

On the staff of this Group is a small team of Landscape Architects whose specific task is the landscaping of these substations. (7) In 1963 one of them read a paper to the Institute of Landscape Architects, (8) and it is mainly on the basis of this that one has been able to examine how they deal with this problem.

Perhaps one should first consider what the problem is, at least from the Landscape Architects point of view. How is a substation likely to offend against existing amenities? In the broadest terms, in two ways. Firstly by presenting a discordant appearance, a complex of radiating transmission lines creating a concatenation of wires, punctuated with electrical equipment and structures; and secondly by noise - from transformers or air blast circuit breakers. An assessment of public opinion expressed in the press and at public enquiries, together with the type of conditions imposed by Planning Authorities on substation development, leads to the conclusion that, at present, concealment is the preferred treatment for substations.

On this type of treatment Lord Holford, the part-time member of the Board for amenity, sounded a warning note, he said (9) there is a 'Shoot-the-pianist' school of criticism which holds that the objects themselves are hideous and inhuman, that no one should pretend they can be made to conform to the humanist principles of architectural and landscape design, and that the only solution is to bury all turbines and reactors, all switchgear and cables underground. He thought that this attitude would be disastrous. It would lower the standard of appearance of all new development, without any compensation in the shape of masterpieces of our own age to set beside those of the past. However, despite this warning from Lord Holford, it is unlikely in the foreseeable future that substations and transmission towers will be regarded by the public as such constructions of beauty, that they enhance the location in which they are situated.

A 400 kV substation will require a site nearly 400 yards long by 220 yards wide which is, approximately 20 acres. This is the net area, the whole of which, except for a 160' strip for a tower reserve along one side, would be enclosed by a security fence, and occupied by electrical equipment supported on concrete or steel structures, the largest of which is a 'goal post' frame about 70 feet high. The terminal towers for this substation would be about 164 feet high. If the substation is both transforming as well as switching a 275 kV compound requiring a net area of about seven acres would be constructed alongside. The tall 'goal post' structures at this voltage are 51 feet high and the terminal towers about 136 feet high. The 132 kV substation by comparison is much smaller, only requiring a net area of about three acres, the tallest structures being 33 feet and the towers about 89 feet high. One can readily appreciate that this complex of electrical and civil engineering at this large scale would not be an easy problem to solve in landscape terms.

A landscape scheme for such a substation evolves from consideration of the need for the scheme to be designed, the conditions influencing or qualifying the need, and the designer's powers of assessing and weighing up that need in relation to those conditions. His function is a dual one and he approaches the problem firstly, as a scientist, examining, analysing and weighing with factual accuracy all the circumstances and conditions on the site, and secondly with the creative power of the artist. The resultant design is determined by the topographical factors such as the size and shape of the site, and its relationship to surrounding land, the climatic and geological factors such as temperature, wind, soil, aspect and moisture conditions, and also economic factors which include cost of construction and subsequent maintenance; and income if it is possible to return land to agriculture or forestry.

The Board's Landscape Architect has said that when he begins to think about a landscaping scheme for a substation, he first makes a careful study of the site. He would note particularly the contours and levels, in order to consider the finished substation level, also any gradients, the amount of cut and fill required and the quantity of material available for ground shaping. He would presumably examine the top soil and subsoil, its acidity and alkalinity, its fertility and crumb structure in order to assess what plants will grow. He would note the existing vegetation, so as to assess what trees are worth retaining or capable of being transplanted, and see what plants are thriving in order to determine the species for new planting. He would also consider the aspect and prospect, to assess those viewpoints which are particularly vulnerable and where screening is necessary.

The Board's Landscape Architect says that he then designs his landscape scheme to achieve four main objectives:-

Firstly, he attempts to integrate the substation into the existing land form and landscape pattern. For this he may propose ground modelling, so that the levels of the substation will appear to flow naturally into the existing contours, and also tree planting in hedgerows around the substation and radiating from it. He may recommend that the operational area of the substation should be surfaced with a dark non-light reflecting material to minimise the contrast with adjoining fields, and that the non-operational areas be surfaced with grass or ground cover shrubs to break up the floor pattern of the substation.

Secondly, to break up the hard silhouette of the structures and associated electrical equipment. To achieve this he may propose general tree planting, and recommend that all structures, plant and buildings should be dark coloured in order that they may be recessive in the landscape.(10)

His third objective is to screen the substation so far as practicable from all public viewpoints. He endeavours to do this by the construction of earth banks adjoining roads, and points of public access, and the reinforceing of existing hedgerows, with general tree and hedgerow planting, in carefully selected positions.

To create a more human environment within the substation becomes his final objective. He hopes to do this by providing lawns, and the planting of ornamental trees and shrubs, the use of patterned paving, flower boxes, bollards, and attention to detail of other hard surface areas. It would appear from a study of those landscaping schemes carried out by the Board that the Landscape Architect also considers three different areas of land associated with the substation, each of which usually requires a different form of treatment.

The first category is land required for tree planting that does not form part of the substation and which is not owned by the Board. This may conveniently be described as off-site planting and may arise for several reasons, for example at the request of the former owner of the land of the substation site for other land in his ownership. All off-site planting undertaken by the Board would be with the willing co-operation of the landowner, and under these circumstances the proposed planting may have to be modified to meet the landowner's wishes.

The second category consists of the area between the boundary of the land the Board owns and the compound security fence. This is the area that forms the major part of the Landscape Architect's proposals. The substation itself is usually level, but if the site is on a slope then the substation may require to be terraced.

The disposal of any surplus material and the design of the banks and slopes would have been carefully worked out with the Board's Civil Engineer to achieve the maximum landscape advantage. It is noted that planting is generally of irregular groups of indigenous trees and shrubs. Formal and exotic planting seems to be avoided, presumably because it would tend to attract attention to the engineering intrusion into the landscape and merely emphasise its presence. Apparently there is no restriction upon the positioning and type of tree that may be planted adjoining the substation compound, except that generally five foot clear space is left on the outside of the security fence for access and maintenance of the fence. It is understood that trees having a leaf of greater dimension than six inches are avoided; because it is alleged that on a wet windy day a number of leaves blew into a substation and stuck on to a stack of insulators sufficient to cause a short circuit. Although it is thought unlikely that a similar incident may recur, the Boards engineers with perhaps an excess of caution are not willing to take the risk. It is not known however how rigidly this objection to six inch leaves is sustained. The Landscape Architect seems to avoid planting trees over underground cables, but it is not quite clear whether this is to protect the cable from mechanical damage by the roots of the trees, or to safeguard the future of the trees, as cables may have to be excavated at sometime or other for replacement or repair. It is observed that trees are not usually planted under overhead lines, because a statutory clearance must be maintained, however, it seems that if it is important to plant trees in such a situation, then an exception can be made and the Landscape Architect selects a tree whose ultimate height would not bring it within the prescribed distance of the conductor.

The third category of land considered for amenity treatment is occupied by structures and electrical equipment, the ground surface being usually gravel, shingle or stone chippings. The Landscape Architect recommends that this hard surface should be kept to a minimum and a local material used provided that it is fairly dark in colour. (11) No planting is done around the electrical equipment. There are also some small areas of land adjoining roads, plant and control buildings, and in these situations some limited planting of small trees and shrubs has been seen but the opportunities appear to be very restricted.

The Board's Landscape Architect works principally in the two media of ground modelling and plants. The modelling of the soil surface being an important part of his design. Of the two materials, land and vegetation, land comes first so far as construction is concerned, though in the design they are considered in their relation to each other. Plants and ground forms are complementary aspects of one sculptural whole - neither alone can give the best results, and in planning the banks and levels, and all the undulations of the ground the landscape designer visualizes these together with the trees and shrubs which will clothe them.

The Landscape Architect says that in preparing his design he endeavours to obtain shallow slopes. Flattened slopes, rounded off at shoulders and toes can be made less obvious, and smooth the substation into the countryside, by generally helping to minimise the scarring effect of the construction. Gang mowers and other grass cutting equipment cannot usually be operated on slopes steeper than 1 in 3, so that the extra cost of acquiring extra land might be offset in the long run by savings in the maintenance costs. A flattened slope is preferred so that any surplus land may be returned to beneficial agricultural use, but from observation it seems that the restrictions of the site often prelude the possibility of this happening.

The Board's Landscape Architect has said (12) that he considers the use of plants in two ways: for a specific purpose, ant then the species appropriate to achieve that purpose. The purpose of planting is a part of the basic structure of the design, for screening, to focalise the view or angle of vision, to prevent soil erosion, to stabilise banks, as wind breaks, and possibly in some small degree to absorb noise. In nature, or in an agricultural landscape, plants are usually massed in large groups of all one kind, or composed of a fairly limited association. The shapes of such natural groups are highly variable according to circumstances of function, topography, and climate, and are for that very reason interesting shapes. The same system, applied in conscious design, gives the best results, and although it may limit the number of species used, it makes for a more satisfactory landscape scheme that a mere collection of horticultural specimens.

To summarise, the Board's Landscape Architect deals with each new substation in five phases:-

1. An assessment of the landscape, and a decision on the relationship to it of the new structures.
2. An overall plan, firm in concept, yet flexible in detail showing the principles to attain this relationship. This forms a framework to which any amendments are referred.
3. A continuing watching brief, during the whole of the planning and civil and electrical construction periods.
4. The final landscape plan for execution when the work is completed, or final plans for such parts of thw work as can be executed from time to time.
5. Arrangements for maintenance.

If landscaping for a substation is required, it is in effect, an admission that the perfect site from a visual point of view has not been selected. As perfection is unobtainable, every site requires some landscaping, to a greater or lesser degree. When the Board refers to landscaping in this context it is used in the widest sense to include ground modelling, and bold tree and shrub planting, designed with a sensitive feeling for the existing land form and indigenous plant growth, in order to mould the substation into the landscape and to create the visual effect of forming part of it rather than an intrusion. The Board's Landscape Architect's guiding principle for landscape design for substations is not to attract attention to what has been done, but to imitate those natural features to achieve as near as possible the perfect site. The success of this work is indicated if the public is not consciously aware either of the existence of a substation or that any landscaping has been done.

11.5 Landscaping of Overhead Lines

So far the emphasis of this chapter has been on the landscaping of substations, and indeed the greater part of the Board's landscaping effort and resources concerned with transmission is directed to this purpose. The overhead line network of the supergrid is however, far more conspicuous and extensive than substations and one should therefore discuss the possibility of ameliorating the visual effect of towers and conductors by any of the techniques of landscaping. (13)

From time to time a suggestion is made, usually in a letter to a local paper, but sometimes by a local authority (14) that trees should be planted to screen transmission towers.

Typical of these suggestions is one recently noticed in a national paper which asked:-

> "Why can't trees of various types be planted at a suitable distance either side of the pylons? In years to come we would have a glorious forest-like belt winding through our countryside, and who could object to so beautiful a camouflage?

When the suggestion is first considered it seems absurd to expect a 6 ft. high slender whip of a tree to screen a 164 ft. high steel lattice tower, but on further reflection one may think the suggestion justifies closer examination.

A Landscape Architect considering this problem would not be likely to plant a tree to screen a tower, but would probably plant trees to diffuse or obscure a view fram any particular position. For instance a 6 ft. high hedge alongside a road may entirely screen the view from travellers. There are many instances of a large tower sited on the bend of a road, which becomes the focus of the view from both directions. A group of half a dozen semi-mature trees about 30 ft. high strategically planted, would be sufficient to diffuse the silhouette of the structure of a steel lattice tower with the twigs of the trees, and at the same time provide a better substitute for the focus of attention. Many more examples could be used to mitigate the worst visual effect of a transmission tower.

It seems that at the moment the Board considers only two possibilities, either to construct a line overhead or by underground cable. Generally speaking if the line is approved for overhead construction, despite some objection, the work proceeds on this basis with the attitude that the visual effect of the proposed line had been thoroughly considered when determining the route and that any resulting detriment to amenity is the price to be paid for the benefit that electricity brings. It is not suggested that landscaping is any substitute for poor line routing not that it affects the basic issue of overhead versus underground.

Photograph 67. 275 kV straight line tower conspicuously sited alongside highway.

Photograph 68. Same view as above but illustrating effect of careful tree planting to focus attention away from tower.

It is simply a case that when the Board resolutely decides against undergrounding, or where a Local Planning Authority reluctantly gives its consent to an overhead line it is offered some small consolation to know that the Board would be prepared to take some active steps by landscaping to soften the visual impact of the line.

The mechanics of such a proposal could be as follows:-

1. When the tower positions are known and the catenarys of the lines worked out, the landscape architect should make a careful analysis of the visual effect of each tower from all public and such private viewpoints as he may gain access. This analysis would include both the immediate environs of the tower as well as its effect in the distant view.
2. This analysis could be annotated on to ordnance sheets at a scale of 1:2500 and by plotting the levels and contours, sections could be drawn to show the line of visual cut off from selected positions to the towers.
3. With this data a further inspection of the terrain should be made to consider where the most effective planting could be carried out, bearing in mind land ownerships and the effect any planting may have on agriculture and road safety.
4. From this information a schedule of tree species, number and height could be prepared and estimates of cost obtained.

It would be expected that from this preliminary study the Landscape Architect would recommend the planting of a single or group of large trees to screen a particularly conspicuous tower sited on a bend in a road. Roadside and verge planting and reinforcing of hedgerows, as well as some limited planting in private properties to screen a conspicuous tower from one of the principal rooms of dwelling.

In considering the landscape possibilities of screening an overhead line it becomes apparent that there are certain legal implications and interpretations that arise. There seems to be four main issues:-

Firstly, and as mentioned earlier under the provisions of the Electricity Act and the Countryside Act the Board has a statutory obligation to have regard to amenity, and this it may do in proposing the route that incurs the least injury to amenity even though it may be more expensive. It may be argued that their obligation does not end there, and that the additional expense for tree screening could well be interpreted as coming within the meaning of the Acts. The Acts do not refer to ownership of the amenity affected, but to the preservation of natural beauty and amenity in general. The Board does not appear to dispute the request to screen its substations or generating stations, and therefore it would seem reasonable to apply the same principle to an overhead line.

The second legal consideration is that a landscaping condition on a planning consent is only enforceable if it refers to land in the a applicant ownership. The Board generally does not own the land on which towers are sited, and therefore a 'landscaped' line is not appropriate to a planning condition, and any attempt to do so would be ultra vires.

The third legal aspect concerns the Board's powers to plant trees. So far as can be discovered there is no impediment to the Board planting trees on somebody else's land subject, of course, to the landowners agreement. (15)

The fourth legal consideration that may influence the Board's officers when contemplating tree planting to screen an overhead line is the provision under various statutes of the powers that Local Authorities have to plant trees. (16)

If the Local Authority elects to plant trees within its area to screen an overhead line, there seems to be no reason why if could not do so at its own cost. However if the request was made to the Board it is not thought that the Board would not be under any legal impediment which would prevent them reimbursing the cost. The Board is reported to have said that money is available for limited schemes of this nature. (17)

What is the Board's attitude to the suggestion of a landscaped line? So far as one has been able to discover from printed sources they have not expressed any, but it is considered that one could form a fairly accurate opinion on what they might be. (18) The probable cost of landscaping a line could be about £2,500 a mile. A 400 kV overhead line costs £65,000 per mile and to landscape it would add about 4% to the cost. At the present time of severe restraint in capital expenditure one would expect the Board to resist this extra cost.

If a policy of landscaping lines became widely adopted the Board may feel apprehensive that it would be swamped with requests to carry out tree planting in every garden in England and Wales from which a tower may be seen. It may be difficult to refuse any bone fide case once the policy became universally accepted, and the financial liability for tree planting of existing lines may become quite considerable. To landscape a line would require hundreds, possibly thousands of small groups of trees, scattered over a wide band of country. To conduct negotiations and obtain agreement with so many landowners, would present a major problem of administration, and more staff to do this work.

If Local Authorities exercised their compulsory powers to plant trees to screen a line against an unwilling landowner, it would be the Board that would receive the brunt of any objection as it is their line for which the tree planting would be required.

The Board tries hard to obtain a favourable public image, and these objections would not help, ant the Board would therefore tend to discourage a Local Authority from exercising these powers in such a case.

Similarly the Board is not likely to encourage Local Authorities to make Tree Preservation Orders on existing trees that screen a line. A T.P.O. is normally made if trees are likely to be felled, and the Board would not wish a T.P.O. to be made against an unwilling landowner.

Of the eight and a half thousand miles of line operated, and over forty-nine thousand towers maintained by the Board there is only one instance on record of the Board offering, instead of being asked to plant trees to screen a line (19). This was the case of the 400 kV line from Cowley near Oxford to Fleet in Hampshire where it was routed to run alongside the Thames between Cholsey and Moulsford. It is not known whether this offer was taken up, but the towers have been recently erected and there is no sign yet of any tree planting.

There are also believed to be one or two instances when tree planting has taken place to screen a tower on the land of the person who was called upon to grant a wayleave for the erection of a tower. It is thought that these exceptions would have resulted from a request by the landowner as part of the negotiations for the wayleave. It is possible that there may also be cases of tree planting to screen a tower on land, which is not affected by a wayleave, but done as a gesture, and not as an obligation by the Board, for the benefit of a person who has objected strongly and vehemently enough to force the Board's attention to the cause of complaint. It has not been possible to find any published references to tree planting for this purpose, possibly because the Board would not wish to increase the number of such requests which would simply make its job of wayleaving and constructing overhead lines that more difficult.

A instance which may help to show the possible attitude of local authorities towards a landscaped line occurred when the Board had extended discussions with Horsham Rural District Council on their suggestion that the Board should carry out tree planting to screen that part of the 400 kV overhead line from Bolney to Lovedean that passes through the Rural District. Following an approach by the writer the Clerk of the R.D.C. wrote as follows:- (20)

> "After very careful examination of the route and consideration of representations made by the Council's officers for groups of trees to be planted near the roadside areas to which the public have recourse, so as to screen the long end-on views of pylons, which were particularly obtrusive, the Board stated that unless it would be demonstrated that well-known beauty spots or views were being interfered with by the pylons, they would not be prepared to spend further public monies on such a project. Indeed, they did state that there were no such well-known views or vistas along the section of the route in this Rural District and my Council were not able to persuade them otherwise.
>
> Another factor was the difficulty in obtaining some security of tenure over the land on which the trees were to be planted and the making of satisfactory arrangements for their maintenance and upkeep so that they became properly established. The Board did make the point that they had spent a considerable amount of money on amenity provision and indeed six million pounds had been spent by the Board during the year ending March 1967, along their main pylon routes throughout the country.
>
> One of the major considerations in the Council's mind in deciding to take no further action to screen the route was that interference had already been caused by the work of erecting the pylons and conductors themselves and it was unlikely that their co-operation would be forthcoming to allow further work to be done in the matter of landscaping. However, this does not mean, of course, that landowners will not themselves seek to carry out long-term tree-planting if they so desire, but nothing is being foisted upon them officially, as it were, and neither are orders being made for the preservation of existing woodland or groups of trees, which help to screen the pylons, which would have been a corollary to any further tree-planting."

One can now readily appreciate some of the difficulties involved if it were advocated to carry out tree planting to screen all the Board's towers, or even those in protected areas of landscape of National Parks, Areas of Outstanding National Beauty and Areas of Special Scientific Interest. However, there are some situations of exceptional significance where the Board should at least be prepared to offer to carry out planting to screen particularly obtrusive towers, for example; in the setting of a building listed as being of historical or architectural interest, or ancient monuments open to the public. Similarly, at well known much frequented beauty spots, or those that enjoy broad panoramic views of unspoilt country, or in situations where the towers overshadow, and destroy the scale and setting of a particularly attractive village or group of dwellings. Many more situations of similar quality will come to mind, but there is no doubt that skilful and sensitive tree planting could greatly reduce the visual impact of towers in these situations. One would wish that the Board would be prepared to make a policy statement of its willingness to carry out tree planting for screening in such similar circumstances and also to put forward the idea of a 'landscaped line' as a third alternative in the overhead versus underground controversy.

11.6 The Board's Landscaping Commitment

This chapter has so far considered why the Board is obliged to carry out landscaping, and has also attempted to set out what the Board has declared to be its policy, and in some detail what their Landscape Architects have said to be their task and design philosopy in designing landscape schemes.

It would now seem relevant to quantify this commitment, and to try and form some assessment of what this means in terms of total acreage and cost.

From a study of the Board's transmission system it has been calculated that there are about 125 existing and proposed primary 400/275 kV substation sites in England and Wales. Of this number it is estimated that about 110 would be landscaped as a condition imposed upon the Board by the Local Planning Authorities. A sample selection of two dozen sites suggests that on average about 20 acres of land would be used for landscaping at each substation site. This would represent a total landscaped area of about 2,200 acres, in hundreds of relatively small parcels of a couple of acres of mainly grassland and woodland throughout the whole of England and Wales.

An attempt has been made to find out the actual and estimated cost to the Board for landscaping its substation sites, but the information is not readily available. Appendix H lists all the published references to substation landscaping one has been able to find in respect of only twenty two sites. In only seven cases were the total cost of landscaping given, as follows:-

Birkenhead	£23,000
Bredbury	£32,000
Burton Green	£80,000
Oldbury	£100,000
Penwortham	£60,000
South Bucks	£25,000
Wymondley	£100,000

The average landscaping cost of these seven sites is approximately £60,000 and the total cost of these sites varies from £2.5 m to £7 m. It would seem that landscaping accounts for between 2.5% and less than 1% of the total cost of a scheme. It has been reported that during the period 1963-67 the Board spent £250,000 on substation landscaping (21), and for the five years between 1963-68 this expenditure for the placing of landscape contracts had increased to nearly £400,000 (22)

It is not stated how many substation sites or schemes this represents, but on the basis of the given estimated total expenditure on landscaping one might expect about 33 schemes to have been completed.

It has also been stated by the Board that the total cost of landscaping all their primary substations sites would be about £1,500,000 (23). The average expenditure in each site would therefore seem to be in the order of £12,000. Later in this chapter an attempt will be made to assess how for this expenditure on these schemes has achieved its objective, but it is now intended to examine the Board's published proposals for future landscaping schemes and to consider whether they make a positive contribution to amenity and the effect if any they may have on land use.

11.7 Evidence of landscape proposals given at public inquiries

From time to time the Board is faced with a public inquiry, as a result of objection to a proposed substation and at these inquiries it is usual for the Board to produce their landscape proposals for the appeal site and to call their Landscape Architect to explain the scheme and to be cross examined.

It would be reasonable to assume that the evidence given by a Board witness at a public inquiry is the policy of the Board which he represents. The landscaping proposals he puts forward must similarly be regarded as the extent of landscaping which the Board regards as appropriate and reasonable in any specific case, to meet its statutory requirement to pay due regard to amenity. It is proposed to extract the relevant evidence from three recent public inquiries, in order to gain a better understanding of how the Board meets this obligation.

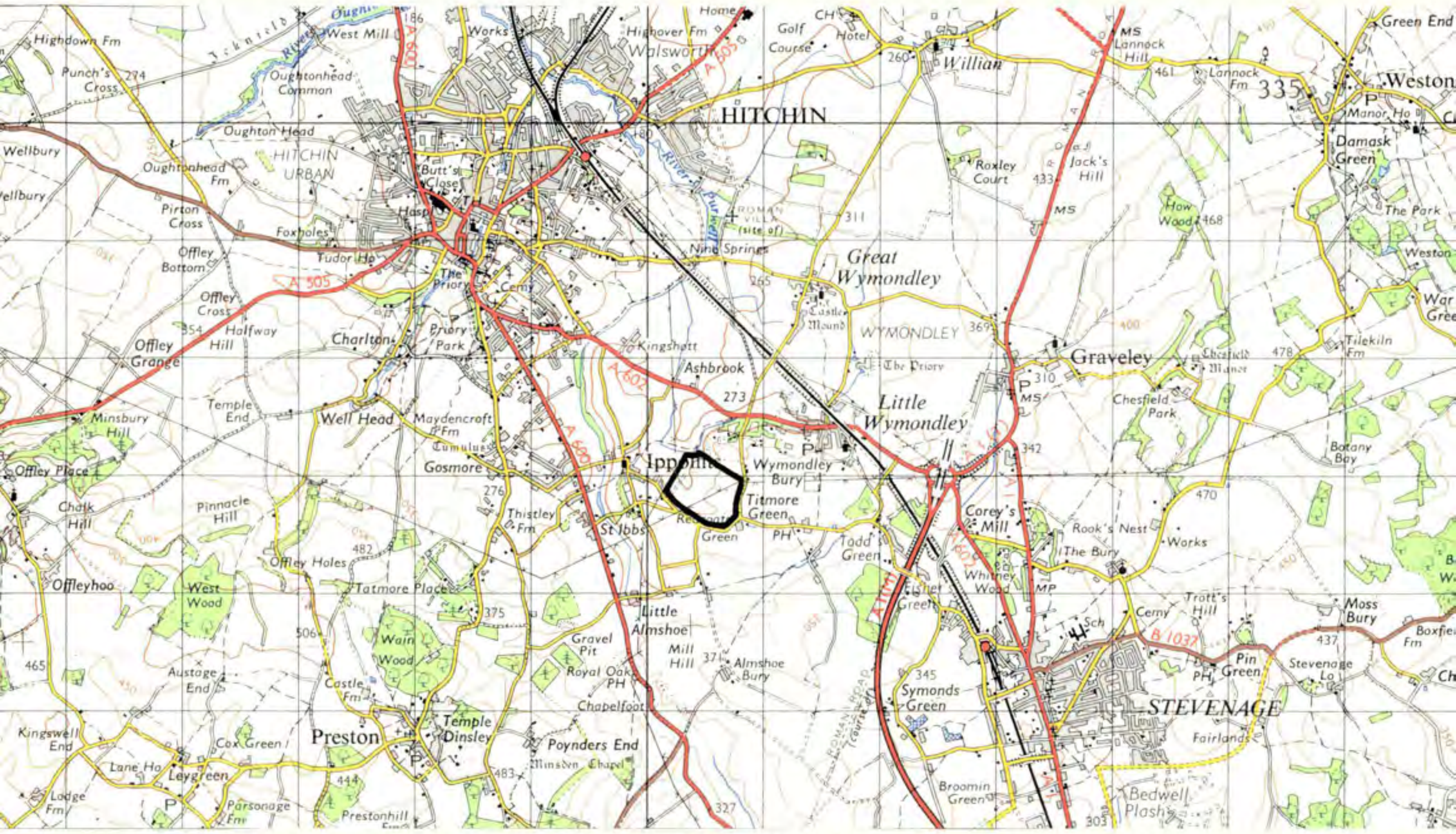
Landscaping for Wymondley Substation

The site of this proposed substation shown on the accompanying map, is situated near the village of Wymondley two miles south of Hitchin in Hertfordshire. It was near to this pleasant village that the Board wished to establish a major 400 kV substation as part of its plan to provide electrical reinforcement to the London area.

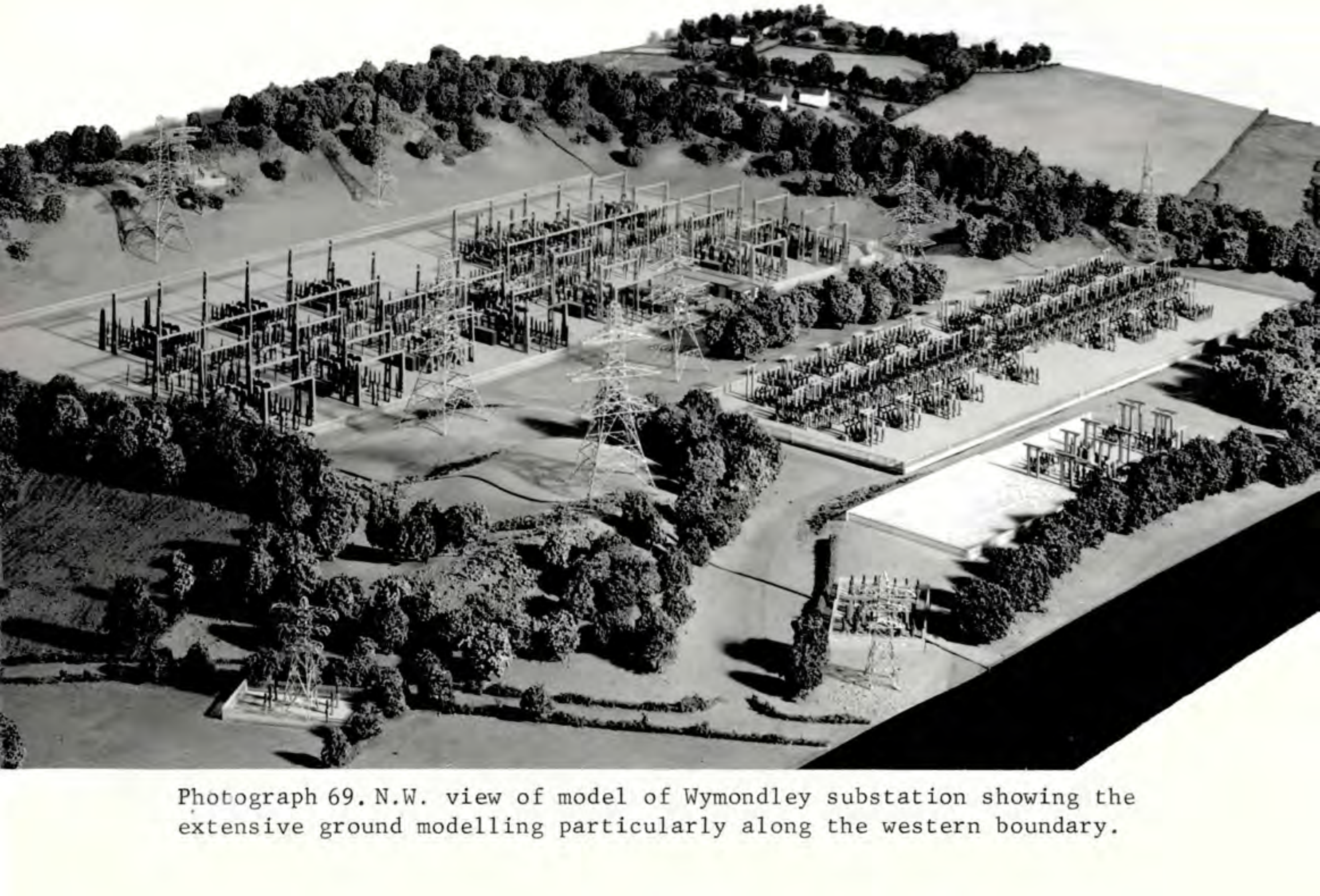
The site was situated in the extended Metropolitan Green Belt and partly because of this, and its proximity to the village it aroused considerable local opposition and a public inquiry was held. (24) This received not only considerable local but also national press coverage and the high cost of the Board's landscaping proposals became one of the main points that received considerable comment. (25)

The Board's landscape witness said that the Board had a statutory obligation to pay regard to amenity and was therefore willing to spend money to achieve a satisfactory solution to the problem of siting this large engineering development in a rural area. The Board proposed to lower the substation floor as much as possible, and to use the excavated material to form screening banks. It was expected that over 600,000 cubic yards of material would be moved in this operation. The total cost of the ground modelling and landscaping would be about £100,000. This included for planting about 1,000 trees and 9,000 hedgerow plants.

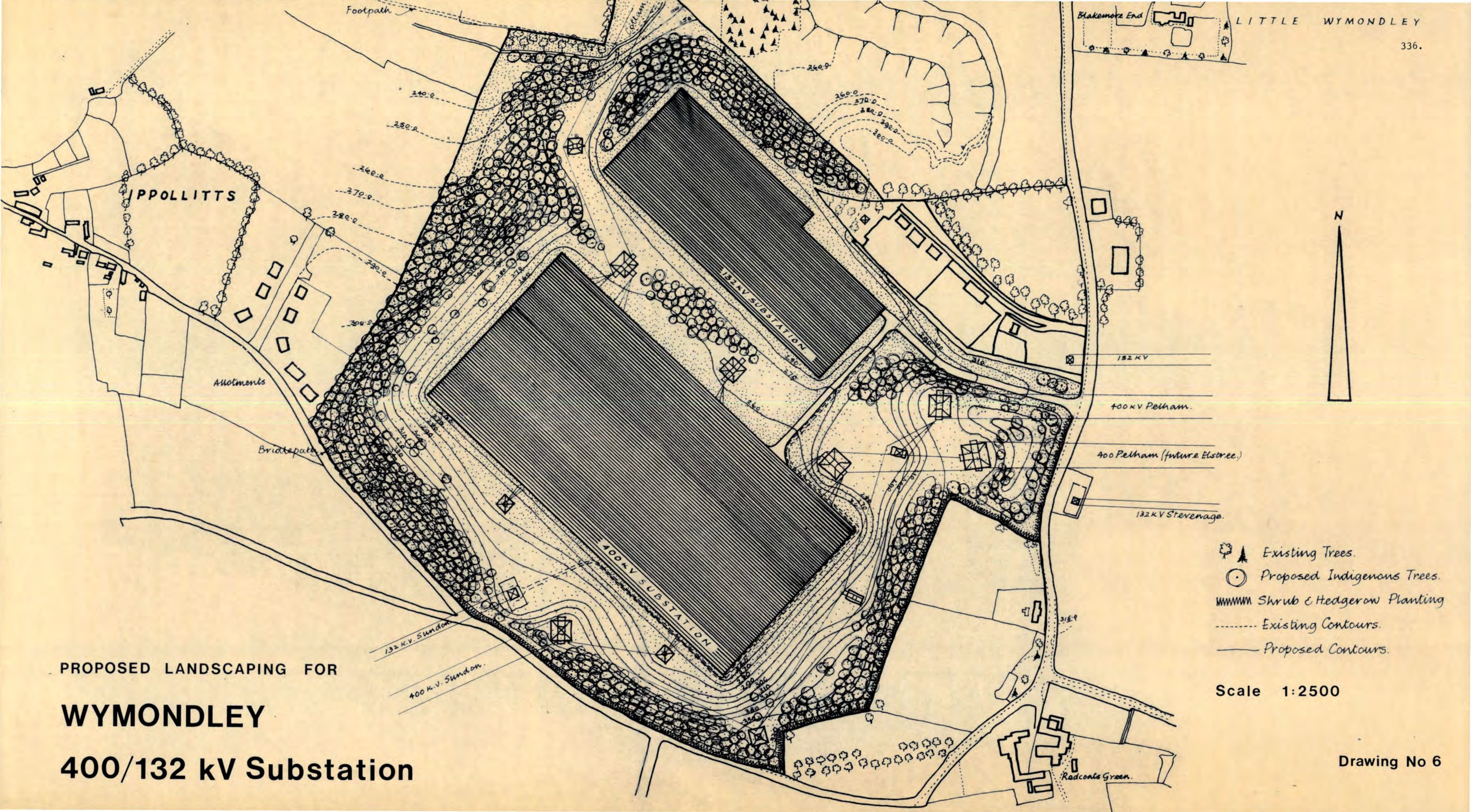
In order to show these landscaping proposals in detail a model had been prepared by the Board which was exhibited at the inquiry. Drawings were also handed to objectors and the inspector, a copy of which is included in drawing no. 6. As an observer at this inquiry one came away with the impression that even the objectors had to reluctantly acknowledge that, although they still vigorously opposed the substation, the proposed landscaping if carried out would effectively screen the substations from most viewpoints.



Map 54 Location of Wymondley 400/132 kV substation, Hertfordshire.



Photograph 69. N.W. view of model of Wymondley substation showing the extensive ground modelling particularly along the western boundary.



PROPOSED LANDSCAPING FOR

WYMONDLEY

400/132 kV Substation

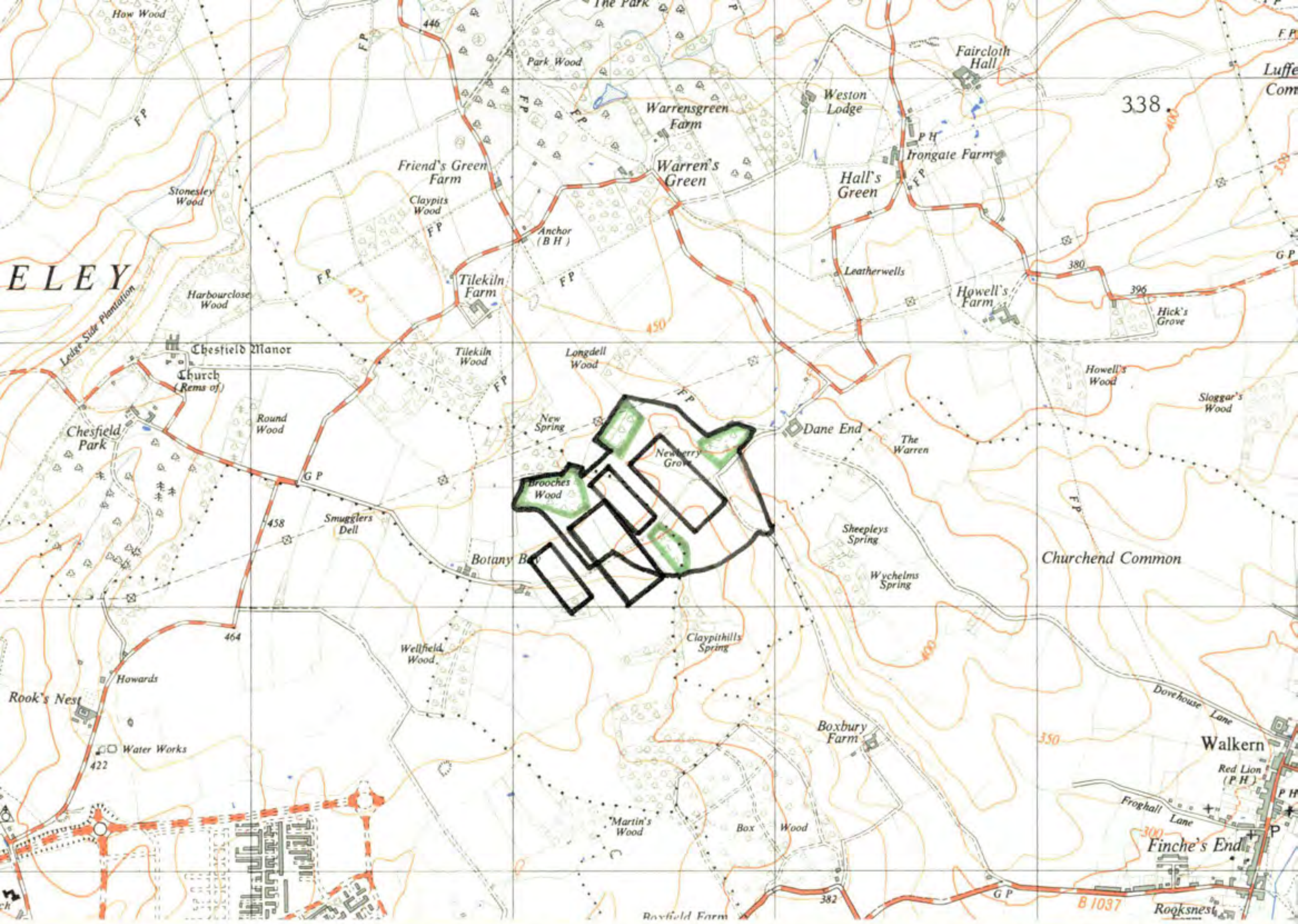
The Minister of Housing and Local Government rejected this appeal and at a subsequent hearing (26) for an alternative site at Botany Bay near Weston in Hertforshire the Board's landscape witness said that the landscaping of this alternative site would cost £65,000. (27) As in the former case the landscaping proposals were illustrated by a model and drawings, and the effectiveness of the screening seems to have depended upon careful siting between existing woodlands, and linking them with new planting, rather that by extensive earth moving. This is illustrated in the accompanying photograph and drawing no. 7.

The Minister subsequently approved the original site at Wymondley, and in his report (28) said that the loss of visual amenity would be minimal because of the extensive landscaping works proposed by the Board. (29)

Landscaping for Burton Green Substation

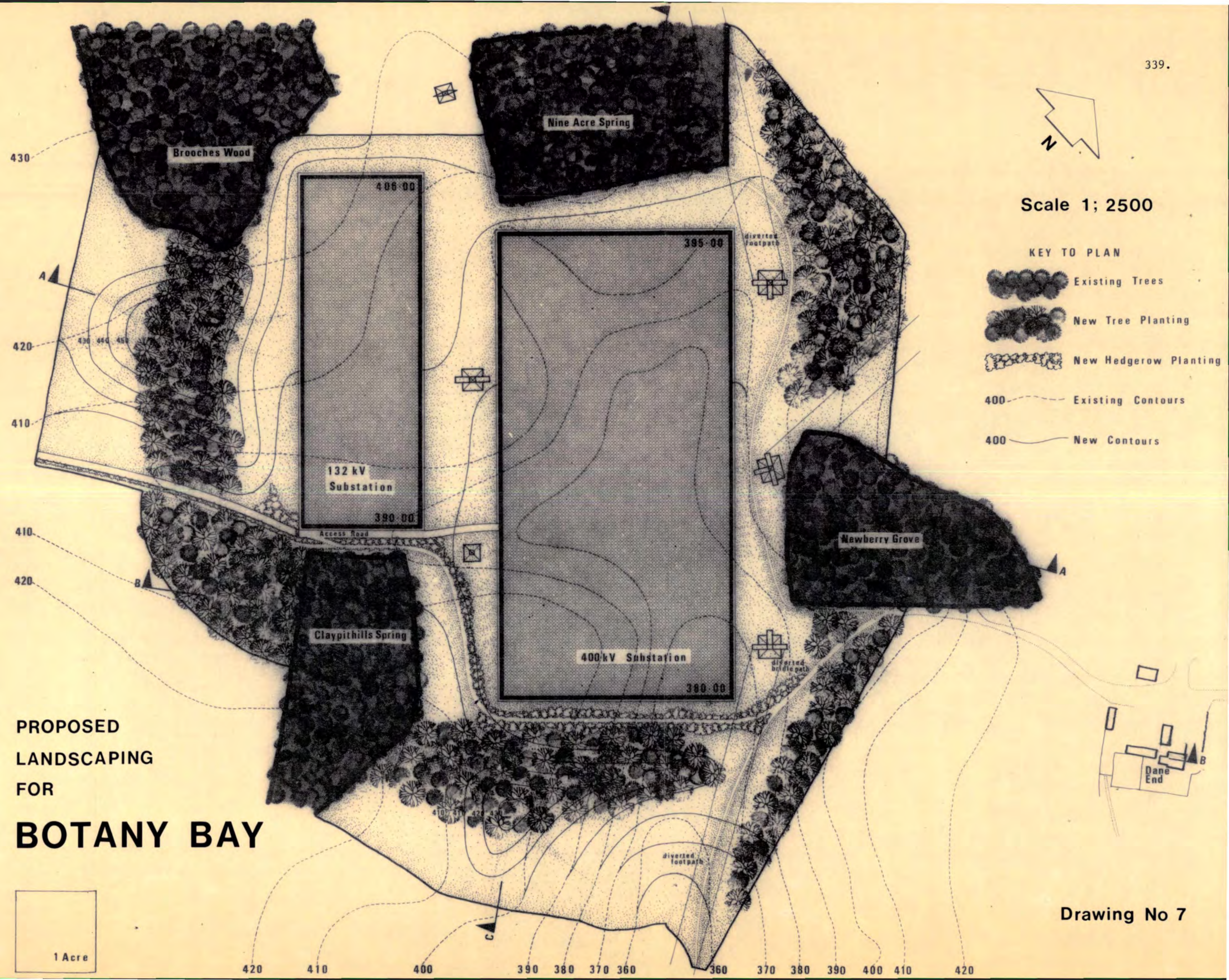
Burton Green Substation is situated five miles south west of the centre of Coventry in the County of Warwickshire and is the Coventry Green Belt. Because of strong local opposition the Minister of Power and the Minister of Housing and Local Government held a joint inquiry. (30)

The landscape witness for the Board said that the Board was anxious to minimise the visual affect of a substation on this site, and with this objective in mind he had prepared a landscaping scheme. He said that the object of the landscaping scheme was not necessarily to ensure that no part of the substation could ever be seen from any possible viewpoint, but rather to take advantage of the existing contours and shape them so that augmented with judicious indigenous planting, the substation would "fit into" the landscape. The Landscape Architect drew attention to a landscape model of the site that he had had made to illustrate his proposals, and he also handed in to the Inspector and had circulated to the public a plan of his landscape scheme.



Map 55 Location of proposed 400/132 kV substation at Botany Bay, Hertfordshire. The map shows how the original siting verged red was slightly modified to take advantage of the screening afforded by the existing woodlands verged green.

Photograph 70 S.W. view of model of proposed substation at Botany Bay. A combination of careful siting retaining the existing woodlands, with new planting would provide effective screening for this site.



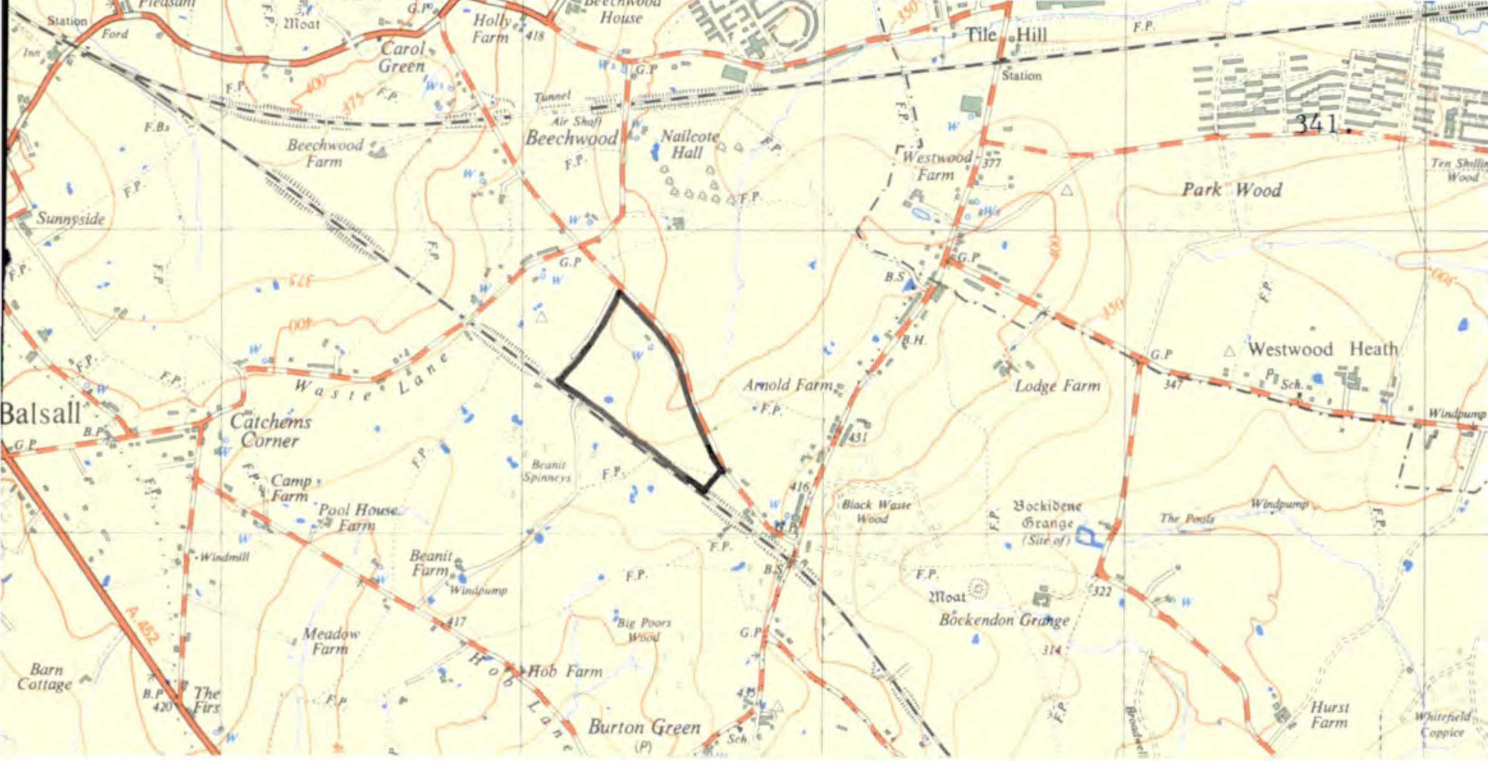
PROPOSED
LANDSCAPING
FOR

BOTANY BAY

Drawing No 7

This plan is included as Drawing No. 8. In explaining his proposals the Landscape Architect said that the ground modelling extending to 30 ft. high along the west side of Hodgetts Lane would be skilfully shaped to provide visual interest and had been designed to flow into the existing contours in order to give as natural an appearance as possible. The mounds would be grassed and planted with indigenous trees and shrubs, and the tree groups would be carried over the top of the mounds to give an interesting skyline and to achieve the maximum screening effect. Along the cart track on the northern boundary of the site all existing trees and hedges which did not interfere with line clearances would be retained and reinforced. In order to obtain the maximum screening to Hodgett's Lane on the east end of the site the substation compounds were moved as far as practicable towards the railway line, nevertheless some tree planting was proposed along this boundary to reinforce the existing tree screen between the railway and Hob Lane. To complete the screening of the site a wide block of trees were proposed along the south east boundary. With the assistance of the landscape model the witness went on to explain that the road into the substation had been curved so that the view into the substation would be substantially concealed with ground modelling and tree planting. The car park would also be screened from the entrance by a wide island of grass, on which it was hoped to retain the existing trees, and to reinforce them with new shrub and tree planting. The Board was also prepared to include some semi-mature trees in its landscaping scheme, in carefully selected positions where an immediate and substantial tree screen was required.

In referring to the phasing of the scheme the landscape architect said that the Board was prepared to carry out all the ground modelling as part of the main civil worke at the first stage of construction.



Map 56. Location of Burton Green 275/132 kV substation, Warwickshire.

Photograph 71 N.W. view of model of substation at Burton Green which was prepared for the public inquiry in order to demonstrate the ground modelling and proposed tree planting to provide screening from the road. The existing hedgerow trees are retained wherever possible and reinforced with further indigenous planting.

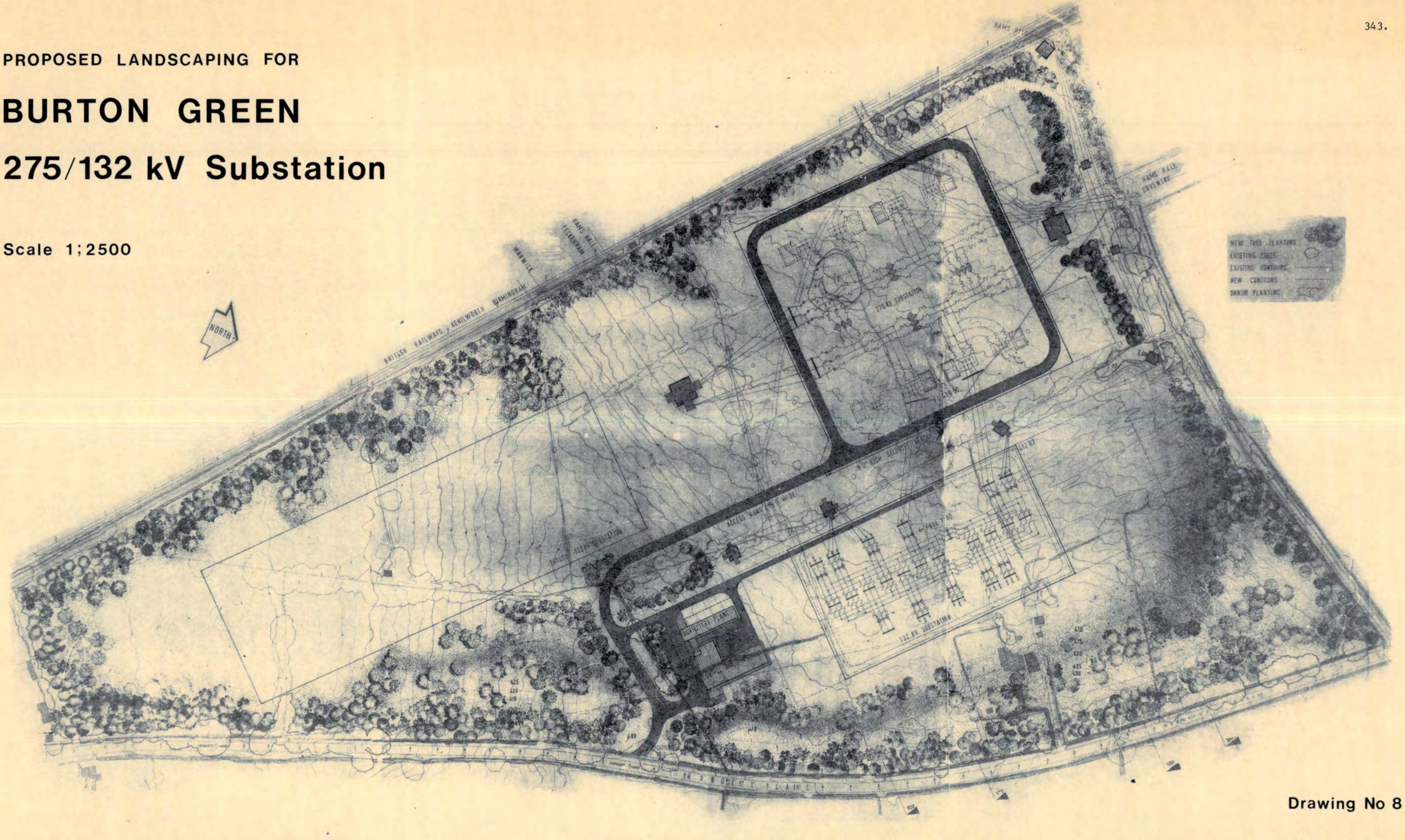
Photograph 72. Air oblique view westwards of proposed Burton Green 275/132 kV substation site. A characteristic of this part of Warwickshire is that the mainly small fields are generously furnished with hedgerow trees. This hedgerow timber provides useful screening for the substation.

PROPOSED LANDSCAPING FOR

BURTON GREEN

275/132 kV Substation

Scale 1;2500



Drawing No 8

Physical screening of the site would therefore be effective from the very beginning. Seeding of the new land form would be undertaken fairly soon after the completion of the earth moving operations, and thus the main visual effect of the development would be hidden whilst the construction and installation of equipment continued. He intended to carry out the tree planting during the first planting season following the completion of the civil and electrical works. A survey of all existing trees on the site would be made, and all trees worth retaining would be moved to new and permanent positions on the site before the start of the main civil works. The Board were anxious to ensure that only the minimum area of land was taken out of beneficial agricultural use, and with this in mind the landscaping scheme would provide where possible, suitable areas for grazing and the Board would endeavour to find a tenant for these areas.

The witness then went on to explain that he was not able to determine with absolute certainty the extent to which the proposed substation would be seen from any dwelling without entering, but that he had formed a judgement by careful study of the topography, vegetation and location of each property. He then gave his opinion how the nearby dwellings would be likely to be affected, and how the landscaping scheme had been designed to take this into account.

During the course of the inquiry reference was made to a critism made by the Warwichshire Branch of the C.P.R.E. to the Minister of Power of the Board's failure to carry out landscaping when they wrote:-

> "In the Midlands area no real efforts have been made by the C.E.G.B. in the past to landscape installations to minimise the effects of such stations on the surrounding areas,................"

In rebutting this statement the Board's Landscape Architect said that every primary grid substation in the Midlands had a landscaping condition imposed in the grant of consent. The Board had, or was in the process of complying with these conditions, and had recently completed landscaping at Coventry and Kitwell substations, and were currently engaged on schemes at Willington, Enderby and Bustleholme. Plans were also in preparation for three more substations.

The witness was not hard pressed under cross examination but a few questions were put by objectors mainly to obtain confirmation of the Board's proposals is so far as it affected their property. The general feeling seemed to be that if the substation had to go there, then the proposed landscaping appeared fair and reasonable and no person present at the inquiry suggested that it should be more extensive, or be modified in any significant way.

The Ministry of Housing and Local Government inspector in his report found as a matter of fact:-

> "....ambitious landscaping proposals which would go far to screen it fully at normal eye-level are an integral part of the intended development."

The inspector appointed by the Minister of Power in his conclusions wrote:- (32)

> "Of the residents in the area, I was satisfied that the Board's proposals for landscaping were such that their amenities would not be unduly affected and consequently there would be no appreciable deterioration in their property values".

The Ministers allowed the appeal subject to the condition that the details of the landscaping and planting shall be substantially in accordance with the drawings submitted at the inquiry. (33) It may reasonably be assumed that the extent of landscaping the Board proposed meets the standard required by the Ministry, which one may consider as the final arbiter of what paying due regard to amenity means in practical terms for a specific site.

Landscaping for South Bucks Substation

Mop end is a small hamlet of half a dozen houses, situated about one and half miles due west of Amersham. It was close to this hamlet that the Board wished to construct a major 400 kV substation, The proposed site was situated in the recently confirmed Chiltern Area of Outstanding Natural Beauty and as might be expected was subjected to considerable objection, and therefore became the subject of a Ministerial public inquiry. (34)

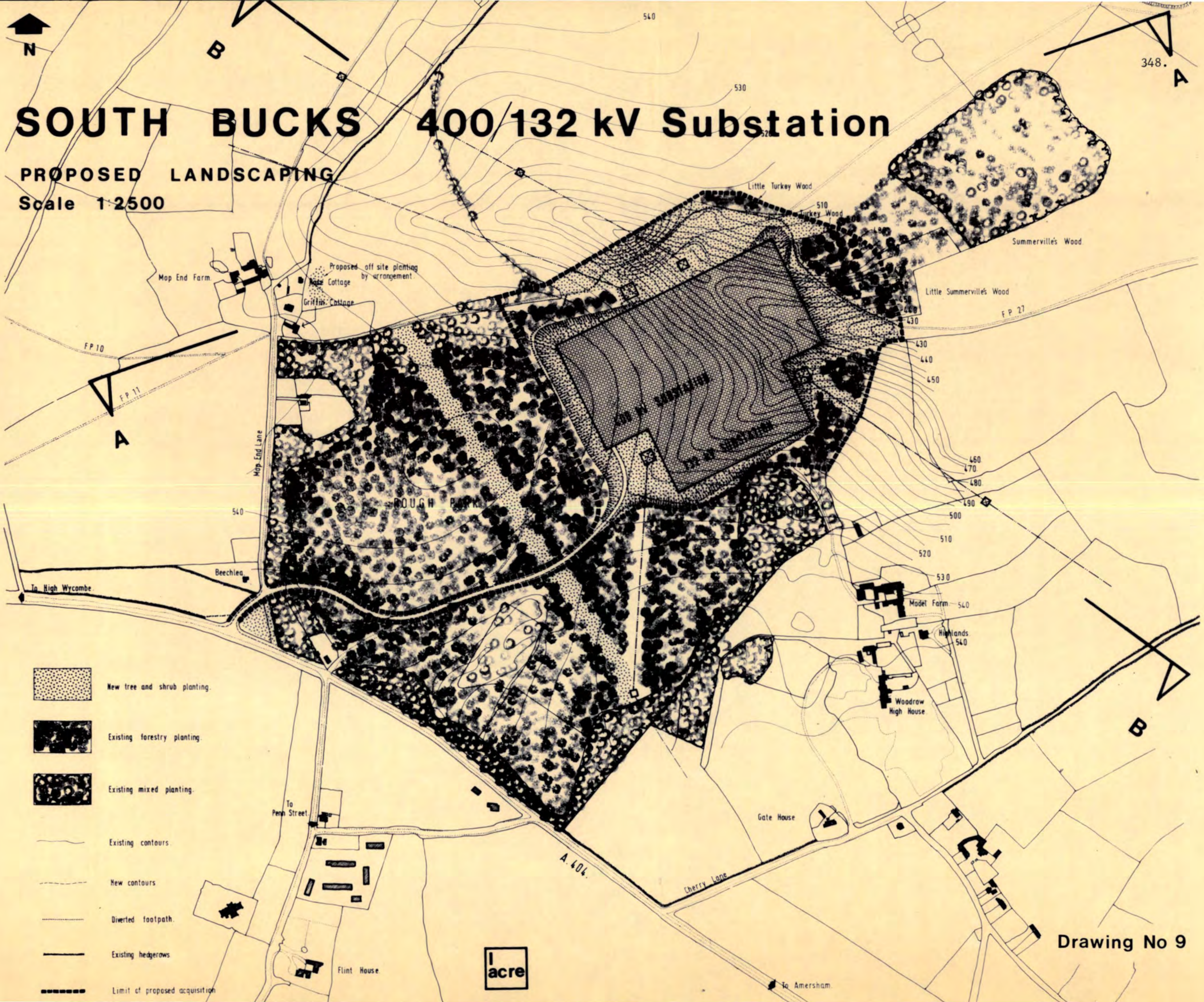
Following evidence on the electrical and civil engineering aspects of the scheme the Boards Landscape Architect handed in drawings of his proposals for this site one of which is included as Drawing 9. He explained that the proposed substation site had been carefully positioned to take advantage of the screening afforded by the existing woodlands. The landscaping scheme had been designed not necessarily to ensure that no part of the substation could ever be seen from any possible viewpoint, but rather to take advantage of the existing contours and shape them so that augmented with judicious indigenous planting the substation would 'fit into' the landscape. The substation structures which are 70 ft. high would be coloured grey to make them recessive in the landscape, would only be seen against a background of trees, and he contended that on this account they would not be obtrusive. He did however agree under cross examination that the terminal towers would be conspicuous, and that the landscaping proposed would do little if anything to screen them.

The landscape witness went on to say that he estimated the cost of landscape works involving tree and shrub planting, seeding and other horticultural operations would cost approximately £25,000. He also offered to carry out tree and shrub planting on private property at the request of the owner if it genuinely helped to screen a view of the substation.

The witness was quickly taken up on this point and it was suggested that thousands of people living nearby at Amersham would be asking to have trees planted in their gardens. The witness replied that he would be happy to oblige in any bone fide case, but his experience was that not very many people would take up this offer. The witness also said that he intended to arrange for the transplanting of about 300 to 400 semi-mature beech trees which were already on the site, to temporary positions whilst construction was in progress, and then replant them in permanent positions to screen the substation. Much doubt was raised by the objectors whether this operation would be successful and it was stated by an expert witness for the objectors that the majority of these semi-mature trees would not survive transplanting. The Board's witness under cross examination said that since 1962 he had been responsible for moving about 700 semi-mature trees between 20 to 40 ft. high of which 90% had survived. The Board had also planted over half a million trees and shrubs, and spent over a quarter of a million pounds on landscaping schemes for similar substation sites.

It is of interest to find out what effect this evidence had upon the Ministry of Power Inspector. A reading of his report indicates that he accepted the Board's contention that the site was naturally well screened and that the proposed landscaping would be sufficient to make the substation visually acceptable. To quote his own words:-

> "In my opinion the layout of the proposed substation at Mop End with its naturally well-wooded surrounding is such that the structures of the substation should be well hidden from general view. Given proper and sufficient landscape treatment, it should be sufficiently well screened, except from certain very local and limited view points, to make the site acceptable in this area from a visual amenity aspect. I have no doubt that the Board would do their utmost to carry out the landscaping in accordance with their recommendations and the undertakings given."


N
B
A
SOUTH BUCKS 400/132 kV Substation
PROPOSED LANDSCAPING
Scale 1:2500
348.
Little Turkey Wood
Summerville's Wood
Little Summerville's Wood
Map End Farm
Proposed off site planting by arrangement
Rose Cottage
Griffin Cottage
FP 10
FP 11
FP 27
Map End Lane
ROUGH PARK
Beechlea
To High Wycombe
Model Farm
Highlands
Woodrow High House
Gate House
A. 404
Cherry Lane
To Penn Street
Flint House
To Amersham
New tree and shrub planting.
Existing forestry planting.
Existing mixed planting.
Existing contours.
New contours.
Diverted footpath.
Existing hedgerows.
Limit of proposed acquisition
acre
Drawing No 9

It is now two years since this inquiry and the Minister's decision is still awaited.

This brief review of the landscaping evidence presented by the Board at three recent public inquiries shows that when hard pressed the Board is prepared to carry out very substantial landscaping schemes. It is however a matter of speculation whether the landscaping proposed by the Board for any specific site would be the same whether there was public objection to the development or not. There is not sufficient evidence to substantiate the frequently voiced opinion that the greater the opposition to the Board's proposals, the greater is the landscaping effort. Certainly the instances quoted represent very substantial and costly landscaping, but of the sites one may see around the country, very few appear to come anywhere near the comprehensive schemes put forward at public inquiries.

11.8 Critical Assessment of Landscaping Schemes Carried Out

Occasionally the Board publishes details and illustrations of some of the landscaping schemes that have been completed on substation sites. This has presented the opportunity to identify the sites and in some instances have enabled them to be visited which is essential if any critical assessment is to be made.

One of the first major landscaping schemes which included extensive earth moving was at Kitwell substation on the south west side of Birmingham. So far as is known, prior to this scheme in 1963, earth moving, shaping and ground modelling had not been seriously considered as a means of screening substations. In this case however the site immediately adjoined an housing estate, a proposed public open space, near to the projected M5 motorway and was partly within the Warwickshire Green Belt.

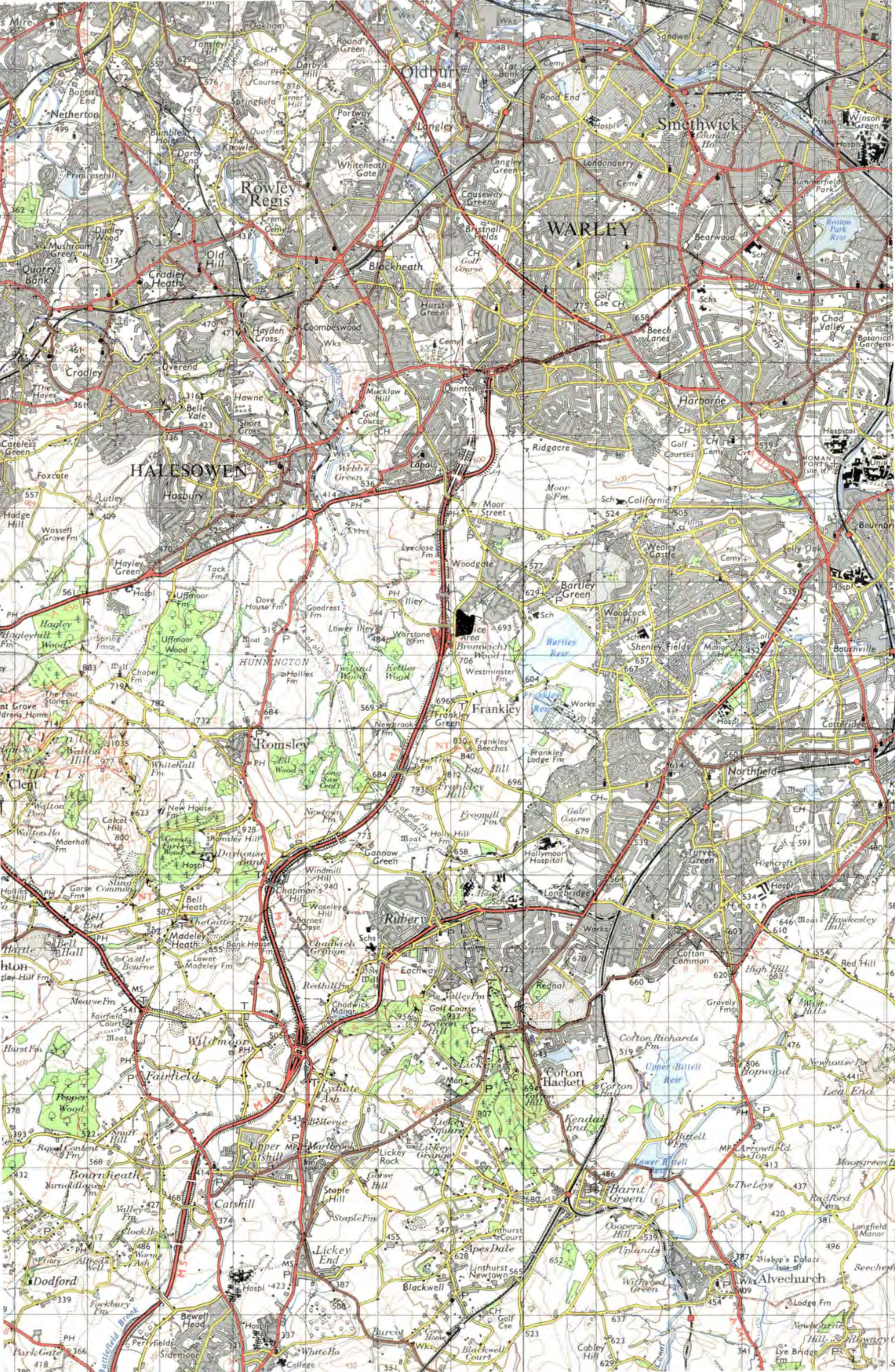
The two local authorities; Birmingham City Council and Warwickshire County Council were particularly concerned of the visual effect of such a substation in this situation. There is little doubt that the local authorities insisted that the Board should undertake extensive landscaping before they were prepared to approve the site. Drawing no. 10 shows the landscape scheme (36) as implemented, and is illustrated by the accompanying photograph (37).

From a recent visit to this site one cannot help but be impressed by the extent of the grand modelling and how effective it is in screening this substation. As far as one has been able to find out no costs for the amenity treatment and landscaping of this site has yet been published, but a quick estimate would indicate that it would be in the order of tens of thousands of pounds.

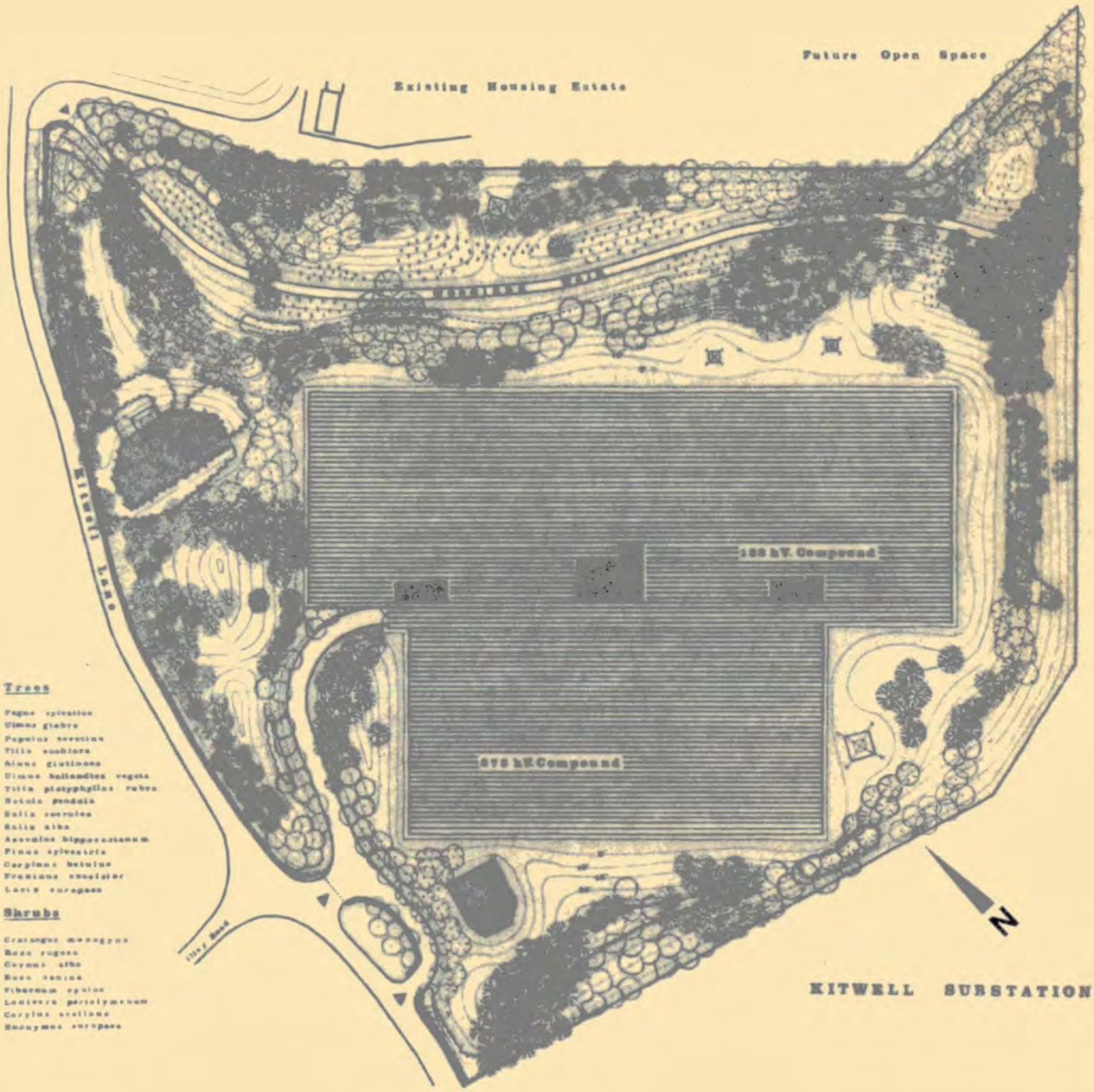
Since the Kitwell scheme in 1963 the Board has adopted major ground modelling as a method of quick and permanent screening on at least thirteen sites (38). From a visit to these sites it is thought that not in every case was the ground modelling motivated by a desire to provide screening, but sometimes as a convenient way to dispose of surplus material resulting from the formation of a level substation area. It would seem particularly apparent in those instances when the amount of material despocited has not been shaped sympathetically to flow into the existing land form and appears rather obviously as an earth bank. If the Board has surplus material to dispose of, it is more economical to purchase a few acres of agricultural land and use it as a tip rather than incur the cost of carting it away. If this tipping of surplus material is sensitively done and provides screening where it is necessary, such expediency can be justified on the ground that it protects visual amenity.

Please turn over for:-

Map 57. Showing the location of Kitwell substation in Worcestershire.



Oakham
Tansley Hill
Round Green
Oldbury
Sandwell
Tat Bank
Rood End
Smethwick
Winson Green
Netherton
Springfield
Turner's Hill
Portway
Langley
Langley Green
Londonderry
Darby Hill
Primrose Hill
Rowley Regis
Whiteheath Gate
Causeway Green
Summerfield Park
Rotton Park Resr
Dudley Wood
Mushroom Green
Quarry Bank
Cradley Heath
Old Hill
Blackheath
Brisnall Fields
WARLEY
Bearwood
Hayden Cross
Coombeswood
Hurst Green
Beech Lanes
Chad Valley
Botanical Gardens
Cradley
The Hayes
Overend
Belle Vale
Hawne
Short Cross
Mucklow Hill
Quinton
Harborne
Careless Green
Foxcote
HALESOWEN
Hasbury
Lapal
Webb's Green
Ridgacre
Moor Fm
California
Lutley
Hodge Hill
Wassell Grove Fm
Moor Street
Weoley Castle
Selly Oak
Hayley Green
Tack Fm
Lyeclose Fm
Woodgate
Bartley Green
Uffmoor Wood
Dove House Fm
Goodrest Fm
Illey
Lower Illey
Warstone Fm
Bartley Resr
Woodcock Hill
Shenley Fields
Hagley Wood
HUNNINGTON
Hollies Fm
Twiland Wood
Kettles Wood
Westminster Fm
Frankley
Bournville
Romsley
Newbrook Fm
Frankley Green
Frankley Beeches
Frankley Lodge Fm
Cotteridge
Northfield
Walton Hill
Clent
White Hall Fm
Egg Hill
Frankley Hill
New House Fm
Newtown Fm
Frogmill Fm
Golf Course
Romsley Hill
Dayhouse Bank
Holly Hill Fm
Gannow Green
Hollymoor Hospital
Highcroft
Turves Green
Sling Common
Bell Heath
Windmill Hill
Chapman's Hill
Waseley Hill
Rubery
Longbridge
Hawkesley Hall
Bell End
Bell Hall
Madeley Heath
Barnes Close
Chadwich Grange
Cofton Common
High Hill
Red Hill
Castle Bourne
Lower Madeley Fm
Eachway
Rednal
Redhill Fm
Valley Fm
Groveley Fm
West Hills
Fairfield Court
Chadwich Manor
Beacon Hill
Cofton Richards Fm
Wildmoor
Upper Bittell Resr
Hopwood
Newhouse Fm
Lickey
Cofton Hackett
Fairfield
Pepper Wood
Lydiate Ash
Lickey Square
Cofton Hill
Lea End
Bellevue
Kendal End
Snuff Hill
Lickey Grange
Bittell Fm
Arrowfield Top
Upper Catshill
Marlbrook
Lickey Rock
Bournheath
Gorse Hill
Lower Bittell Resr
Moorgreen Hall
Barnt Green
The Leys
Staple Hill
Radford Fm
Catshill
Staple Fm
Coopers Hill
Uplands
Langfield Manor
Linthurst Court
Lickey End
Apes Dale
Linthurst Newtown
Bishop's Palace
Alvechurch
Withybed Green
Dodford
Blackwell
Lodge Fm
Bewell Head
Burcot
Blackwell Court
Cobley Hill
Lye Bridge
Perryfields
Sidemoor
White Ho
Park Gate



Scale 1 inch to 176 feet approx.

Landscape plan for Kitwell substation near Birmingham. M.R.992814. The first major landscaping scheme for a primary grid substation by the C.E.G.B. The contours indicate the extensive ground modelling carried out at this site. The substation is in effect surrounded by a 40 ft. high mound with considerable tree and shrub planting.

Drawing No 10

Photograph 73. A general view south-eastwards along the woodland walk linking Kitwell Lane with the housing estate and the proposed public open space. The photograph was taken in October 1966 soon after the tree planting had been completed, and illustrates how effective the ground modelling screens the substation from the public footpath.

The following series of photographs of substations at Bolney, Coventry, Hurst, Lovedean, and Ninfield, illustrate the different ways in which grand modelling and earth shaping, with and without tree planting can form an important part of the landscaping of a site.

The principle means of screening a substation is by tree planting, and every substation site landscaped had been extensively planted with trees. Occasionally semi-mature trees had been planted, but it seems that the advantages hoped for by using larger trees were frequently frustrated by losses caused by lack of attention to staking, tying, and watering during the establishment period.

11.9 Landscape Maintenance

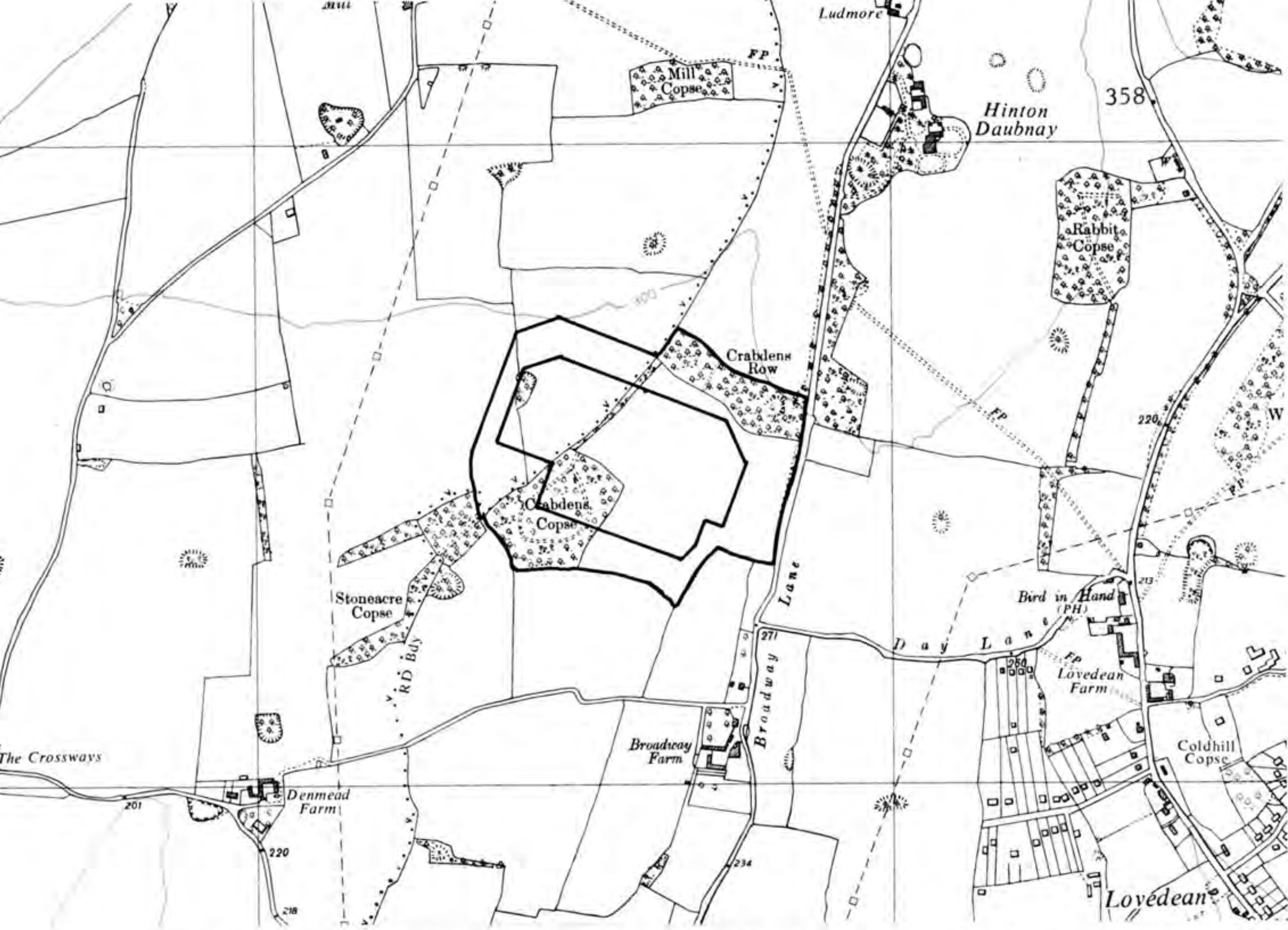
It appears that the Board has spent, and is committed to spending one and a half million pounds over a period of ten years on landscaping operations consisting mainly of land reinstatement, grass seeding and the extensive planting of thousands of trees and shrubs (39).Landscaping, as any other form of capital equipment, must be maintained properly if the capital expended is to be justified and the purpose achieved.

The Landscape Architect designs a scheme having in his mind the long term effect he wishes to achieve. This result cannot be attained unless it is properly maintained in accordance with good horticultural and arboricultural practice. It is not expected that the Landscape Architect would cease to be interested in the growth of his scheme once the contract was finished, but that he should maintain a continuing interest thereafter. Similarly the person responsible for supervising landscape maintenance in order to carry out his job effectively must be aware of the long term design objectives. Thus those two spheres of activity must be equal and complementary if the end result is to be satisfactory.

Photograph 74. Illustrating how the retention of mature trees at the entrance to Bolney Substation with the new tree planting and modest ground modelling has helped to screen and diffuse the 70' high steel supporting structures. Bolney substation is situated between Bolney and Cowfold in south-east Sussex. The site was already reasonably well screened on the south and west boundaries which have been augmented by further tree planting of indigenous species. The surplus material from the site levelling was used for ground modelling chiefly on the northern boundary of the substation and to a lesser degree on the western side of the access road. An existing dew pond was enlarged, planted with aquatic flora, and restocked with fish for the benefit of the local angling society who formerly fished there. In addition to the standard size trees, some semi-mature trees were also planted, to close particularly vulnerable viewpoints. The total cost of tree planting and ground modelling was in the order of 2½% of the total cost of the substation.

Photograph 75. View of Coventry substation from the access road. Modest ground shaping and a few recently planted trees have the effect of focusing attention to the foreground and 'smudging out' the substation behind.

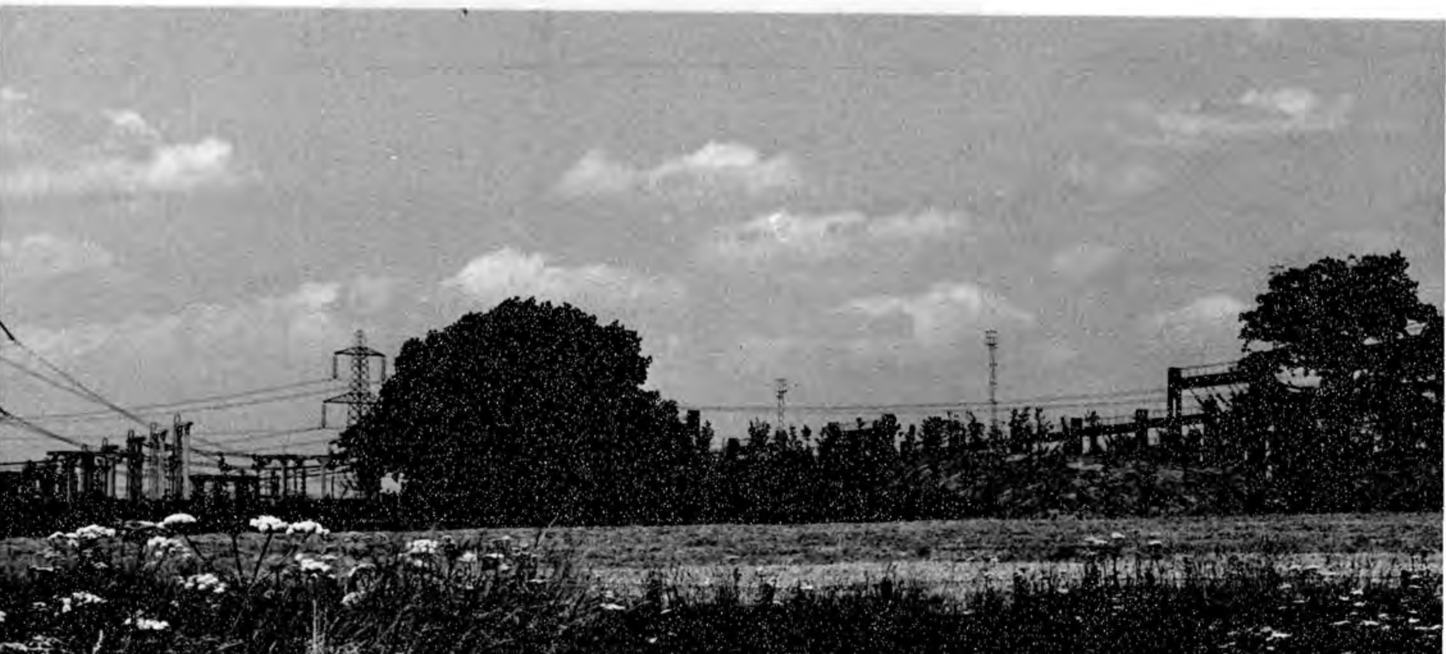
Photograph 76. Air oblique view of Hurst 275/132 kV substation looking westwards. London Borough of Bexley. M.R.489730. This photograph taken on Wednesday, 9th April 1969 shows the substantial completion of the preliminary earthworks just prior to grass seeding. This site is generally regarded as being a very good one from a visual amenity point of view as the substation has been carefully located between Sands Spinney to the top right of the photograph, Cavey's Spring in the bottom right, and a Forestry Commission Plantation on the left. The only vulnerable aspect was to the east of the site where land modelling 40 ft. high has been carefully designed and shaped to provide a line of visual cut off for the occupants of dwellings further to the east. Planning permission required a landscaping scheme of which the ground modelling formed the first stage. The second stage tree planting will be carried out next year in order to clothe the new land form, and to complete the screening of the whole site. The care taken in site selection and landscaping will help to ensure that when the substation is finished it is unlikely that any of the local residents will even be aware of the existence of this major switching and transforming station in their neighbourhood.



Map 58. Lovedean substation, Hampshire. M.R.676135 sited to take advantage of the screening afforded by the existing plantations of Crabdens Row and Crabdens Copse.

Photograph 77. The entrance to Lovedean substation showing how the ground modelling and new tree and shrub planting provides screening for most of the substation. In a few years time one would expect the tree screen to hide the substation entirely from this view.

Photograph 78. Lovedean substation, taken in October 1966, soon after the completion of the ground modelling.



Photograph 79. Same view as above taken in July 1969 soon after the completion of the tree planting. Some diffusing of the substation structures is already apparent, and in a few years time one would expect the trees to completely screen the substation from this view.

Photograph 80. View of Ninfield substation in East Sussex from the access road. See also Maps 36 and 37 and Photograph 40. The photograph illustrates that ground modelling on a considerable scale has been carried out in order to make the substation 'fit into' the existing land form and to screen it from the adjoining highway. The ground modelling and tree planting is said to be 0.35% of the total contract cost. A considerable amount of earth moving was necessary to form a level for the substation, the surplus material being used for the ground modelling. The landscaping in this case represents a financial saving to the Board by using to advantage the surplus material rather than having it carted away.

The Landscape Architect is designing a scheme would be mindful of the manner in which it would require to be maintained, and in the case of schemes prepared for the screening of substations economy and ease of maintenance would be major considerations. A landscape scheme is designed however to meet certain visual amenity requirements, to screen certain viewpoints, to provide a background to a substation to prevent it appearing on the skyline and so on. Such a landscape scheme may be limited by the area of land available for ground modelling. The primary purpose of a landscape scheme is not therefore to design it specifically for ease of maintenance, but to create an external environment that is aesthetically acceptable to all those using and seeing the substation. The landscape designer is fully aware of the need for ease of maintenance but the maintenance requirements have often to be compromised because of these other over-riding considerations. For instance, it is desirable for ease of maintenance or in order to return land to agriculture to have screening banks at a shallow gradient, and for a given height this will require a certain area of land, but if for other reasons, such as an unwilling vendor or the possibility of having to make a Compulsory Purchase Order, the slopes may need to be steeper. The increased cost of subsequent maintenance is the cost penalty the Board has to bear because of these other factors which tend to become forgotten and perhaps is not even known or appreciated by the public or the person responsible for subsequent maintenance.

One should always remember that from the Board's point of view the electrical requirements are the most important consideration. There would be no need for the landscaping if it were not for the substation, and a substation is not a once and for all exercise, but is subject to continual alteration, both to the equipment and the overhead line connections. Any landscape designer should always bear in mind that his scheme may be subject to major alterations at any time. Therefore what is at first conceived as a scheme of minimum maintenance may over the years turn out to be costly in maintenance because of the alterations necessitated by the changed electrical requirements. For example, a double circuit 400 kV cable laid will cost something about £500 per yard, and any potential saving in landscape maintenance costs would be absurd if it required any lengthening of such a cable. So what often appears on the face of it to be bad landscape design resulting in costly landscape maintenance is generally the result of over-riding electrical requirements.

As part of this study the general appearance of the Board's substations was specially observed. In the majority of cases it was disappointing. None of those visited could be described as excellent, one or two achieved the standard one should expect from a responsible national authority, the majority were bad, and some were a disgrace to those responsible for their care. On every site there were dead or dying trees, badly staked or guyed, shrub borders overgrown with weeds, uncut grass, and considerable quantities or rubbish which seemed in most cases to be the residue from the construction of the substation.

11.10 Conclusion

The beginning of this chapter attempted to explain why the Board carried out landscaping, and its officially declared policy.

It is unfortunate that the only authorative source of information on the Board's landscaping proposals seem to be given somewhat reluctantly at public inquiries, and because of this there is a danger that they may not be truly representative of the general standard the Board adopts.

To judge the Board by its results seems to indicate at least to one investigator, that it fails to achieve what it is statutorily obliged to do, and says what it is prepared to do. One might conclude that the Generating Board which of its very nature is essentially an engineering organisation, pays lip service to have regard to amenity, but does not really care, nor is prepared to set up the machinery to look after the considerable acreage of land which it has landscaped at so great a cost. The Board is failing in this aspect of its statutory duty and it is incumbent upon the public by representation to the Board and through Parliament to remind it of its responsibility and to be vigilant to see that the Board carries out its obligation in the spirit as well as the letter of the law.

CHAPTER ELEVEN

References

1. A copy of Section 37 Electricity Act 1957 is included as Appendix G.

2. A copy of Section 11 Countryside Act 1968 is included as Appendix H.

3. C.E.G.B. Annual Report 1961, P.9., also in Power News, September, 1961.

4. C.E.G.B. Power and Countryside by R.E. Wacher. Chief Wayleave Officer, published July, 1965.

5. Power Supply for 1970 by E.S. Booth, C.E.G.B. member for Engineering, published in Proceedings of Institute of Electrical Engineers, January 1967. Paper 5164P delivered before the Power Division on 26th October, 1966. Reprinted by C.E.G.B., April 1967.

6. Report from the Select Committee on Nationalised Industries, Vol. II, paragraph 908.

7. Given in evidence at C.E.G.B. Public Inquiry at Coleshill, Warwickshire 12.10.66.

8. The Landscape Problems Associated with the Development of Electricity Substations. Paper read by G.A. Goulty to the Institute of Landscape Architects on 21st March, 1963.

9. Power Production and Transmission in the Countryside. Paper read by Sir William Holford to the Royal Society of Arts on Wednesday, 25th November, 1959, published by C.E.G.B., P.23.

10. It is interesting to note that during the second world war aerial observation tests were made in conjunction with the Camouflage Department of the Ministry of Home Security to investigate the best treatment for concealing substations. The principal measures finally taken were the darkening of the granit chips used as a ground covering in many substations and the camouflage painting of structures and buildings. The buildings were further concealed by the planting of trees and shrubs. British Grid System in War Time by Hacking and Peattie published in Journal of the Institute of Electrical Engineers October, 1947, Pages 463 & 464.

11. The Board's Landscape Architect has given evidence to this effect at several Public Inquiries.

12. The Landscape Problems associated with the Development of Electricity Substations. Op. cit.

13. The idea of tree planting to screen a line from a highway was casually mentioned in a short article in an American journal which was advocating the use of a transmission line right-of-way for recreational purposes. Electrical World. 10th October, 1966, page 31.

14. Horsham R.D.C. resolved to invite the C.E.G.B. to discuss the possibility that trees be planted at strategic points along the rural route of the proposed Bolney to Lovedean 400kV overhead transmission line. West Sussex County Times 30.10.64. Following a series of meeting with the C.E.G.B. over a period of three and a half years it seems that the difficulties were too great and the proposed tree planting was abandoned. Evening Argus 23.5.68.

15. Off site planting has been proposed for Drax Power Station. Land would remain in present ownership and planting would be carried out by agreement with the landowners. The Board offered to meet the cost of the planting. Goole Times 2.2.68. The Boards Landscape Architect also offered tree planting to screen towers on any objectors land when giving evidence at public inquiries at Hitchin 28.9.65, Dorchester 3.5.66, Coleshill 12.10.66, Hitchin 4.1.67. and at Amersham 22.8.67.

16. The first Act enabling the planting of trees appears to be the Commons Act 1876, Section 5, (copy enclosed as Appendix 'K') which provides for the improvement of a Common by, inter alia, the planting of trees. Section 89 of the National Parks and Access to the Countryside Act 1949 (Appendix 'L') gives powers to all local planning authorities to plant trees on land in their area for the purpose of preserving or enhancing natural beauty. These are comprehensive powers to plant trees, on land whether owned by the Local Authority or not. It also permits other persons to carry out the planting. The Authority can also acquire land compulsorily for this purpose. The Highways Act 1959, Sections 65 and 82 (Appendix 'M') enables Highway Authorities to plant trees and shrubs in the central reservation of dual carriageways, at roundabouts and in the verges alongside roads. The Highways (Miscellaneous Provisions) Act 1961, Section 5 (Appendix 'N') extends these powers to permit the Highway Authority to maintain trees whether planted by them or not. The Civic Amenities Act 1967, Section 12 (Appendix 'O') lays a duty on Local Planning Authorities to ensure that a tree planting condition is imposed on all appropriate Planning Consents.

17. West Sussex County Times 24.5.68.

18. The reluctance of the Generating Board to adopt the idea of a landscaped line was shown at a Public Inquiry into a 275/132kV line between Tynemouth and Gosforth held at the Northumberland County Council Offices at Newcastle on 12th - 14th November, 1968. The solicitors for the Board said that following discussions with the County Planning Officer the Board's Transmission Project Group Landscape Architect had prepared a tree planting scheme for the screening of approximately two and a half miles of this overhead line. The Board, although asked by the Inspector to present its

landscape proposals, declined for the reason that it may prejudice its discussions with the Local Planning Authority.

19. Oxford Times 22nd April, 1966.

20. Letter reference JFG/DB/TCP/PU.1/1 dated 20.11.68 from P. Soothill. Clerk of Horsham R.D.C.

21. Reading Evening Post 25th August, 1967.

22. Span Vol. 4., No. 8., July 1968, Page 2. Span is the House Magazine of the Transmission Project Group, C.E.G.B.

23. These figures are quoted from page 7 of the published proceedings of a Symposium held at the C.E.G.B. Headquarters in London on Economy in Landscape Maintenance.

24. The Inquiry was held at the Hitchin Rural District Council Offices on the 28th and 29th September, 1968, and the information in this chapter was derived principally from this source, but supplemented by extensive press reporting.

25. Daily Telegraph. 29.9.65. Times 29.9.65. The Guardian 4.10.65.

26. Held at Hitchin Rural District Council Offices on the 4th to the 11th January, 1967.

27. The Guardian 6.1.67.

28. Decision letter from Minister of Housing & Local Government reference APP/2152/A/11704 dated 13th September, 1967.

29. Hertfordshire Express 21.8.67. Hitchen Pictorial 22.8.67.

30. The Public Inquiry was held at Meriden Rural District Council Offices, Coleshill, Warwickshire, on 12th to the 19th October, 1966. The landscape architect witness read from a proof of evidence, copies of which were circulated, and from which this summary is made.

31. Report dated 16th December, 1966, reference 2243/A/8659, page 17, Inspector Charles Johnson F.R.I.C.S.

32. Report dated 16th January, 1967, reference EL.72/16/A21, page 33. Inspector L.G. Hambrook C.Eng., A.M.I.E.E.

33. Decision letter from Minister of Housing & Local Government, reference P14/APP/2243/A/8659 dated 22nd June, 1967.

34. This Inquiry was held on the 22nd to the 25th August, 1967, at the offices of Amersham Rural District Council. Copies of the Landscape Architect's proof of evidence and drawings were made available to the

public, and is the source of this summary.

35. Report dated 30th November, 1967 reference EL.72/16/A35 page 31 paragraph 1. Inspector W.L.M. French C.Eng., MIEE., M.Inst.F.

36. This drawing is a reduced copy of the one exhibited in the design section at the 1966 Chelsea Flower Show.

37. Photographs of the landscaping at Kitwell have been published in the C.E.G.B. Annual Report 1965, and Power & the Countryside published C.E.G.B. July 1966. Page 16.

38. The following substation sites at which extensive ground modelling has been done have been visited by the writer. Bolney East Sussex, Burton Green Warwickshire, Canterbury Kent, Chickerell Dorset,, Coventry Warwickshire, Feckenham Worcestershire, Fleet Hampshire, Hurst Kent, Lovedean Hampshire, Ninfield East Sussex, Oldbury Worcestershire, South Manchester Cheshire, and Willington Derbyshire.

39. Economy in Landscape Maintenance Symposium op. cit.

Appendix A

Annual Total Length of Main Transmission Lines in Service

Year Ending	400 kV		275 kV		132 kV	
	Route Miles	Percentage	Route Miles	Percentage	Route Miles	Percentage
March 1949	Nil	Nil	Nil	Nil	3,699	-
" 50	"	"	"	"	3,753	+14.6
" 51	"	"	"	"	4,037	+ 7.6
" 52	"	"	"	"	4,105	+ 1.7
" 53	"	"	41	"	4,174	+ 1.7
" 54	"	"	161	+292.7	4,496	+ 7.7
" 55	"	"	325	+101.8	4,754	+ 5.7
" 56	"	"	464	+ 42.7	4,354	- 8.4
" 57	"	"	557	+ 20.0	4,494	+ 3.2
" 58	"	"	726	+ 30.3	4,814	+ 7.1
" 59	"	"	926	+ 27.5	5,050	+ 4.9
" 60	"	"	1,316	+ 42.1	5,361	+ 6.2
" 61	"	"	1,488	+ 13.1	5,734	+ 6.9
" 62	"	"	1,687	+ 13.4	5,878	+ 2.5
" 63	"	"	1,852	+ 9.8	6,039	+ 2.9
" 64	"	"	1,915	+ 3.4	6,183	+ 2.4
" 65	"	"	2,023	+ 5.6	6,492	+ 5.0
" 66	203	"	1,997	- 1.3	6,840	+ 5.4
" 67	827	+307.4	1,975	- 1.1	6,773	- 1.0
" 68	1,296	+ 56.7	1,648	- 16.6	6,694	- 1.2

Notes:

1. Figures for route miles obtained from Annual Reports of British Electricity Authority, Central Electricity Authority, of Central Electricity Generating Board as appropriate.

2. The Electricity Supply industry was nationalised on April 1st 1948 and the earliest national statistics available are those for the year ending 31st March 1949.

3. All figures give mileage of line according to the type of construction of line which is not necessarily operating at the stated voltage.

4. All figures are inclusive of overhead and underground lines.

5. All figures have been rounded off to the nearest whole number.

6. Percentage is increase or decrease over previous year.

Appendix B

Annual Capital Expenditure on Main Transmission in £million

Year ending	£ million	Percentage
March 1949	£11.5	-
50	£15.784	+37.3
51	£24.0	+52.1
52	£23.0	- 4.2
53	£30.0	+30.4
54	£20.0	-33.3
55	£24.9	+24.5
56	£32.6	+30.9
57	£36.7	+12.6
58	£32.0	-12.8
59	£31.0	- 3.1
60	£35.1	+13.2
61	£31.2	-11.1
62	£41.2	+32.1
63	£56.7	+37.6
64	£76.4	+34.7
65	£106.1	+38.9
66	£130.9	+23.4
67	£162.8	+24.4
68	£151.3	- 7.1

Notes:

1. Figures of expenditure obtained from the Annual Reports of the British Electricity Authority, Central Electricity Authority, or Central Electricity Generating Board as appropriate.

2. The Electricity Supply industry was nationalised on April 1st, 1968 and the national statistics available are those for the year ending 31st March, 1949.

3. This expenditure refers to both grid and supergrid transmission.

4. Percentage is increase or decrease over previous year.

Appendix C

Progressive annual length of Main Cables in Service

Year Ending	400 kV		275 kV		132 kV	
	Route Miles	Circuit Miles	Route Miles	Circuit Miles	Route Miles	Circuit Miles
March 1949	Nil	Nil	Nil	Nil	35.60	Not available
" 50	"	"	"	"	42.74	66.76
" 51	"	"	"	"	45.25	77.78
" 52	"	"	"	"	62.20	101.88
" 53	"	"	"	"	67.16	107.98
" 54	"	"	"	"	78.60	124.05
" 55	"	"	"	"	86.49	138.07
" 56	"	"	"	"	68.86	112.86
" 57	"	"	"	"	90.53	147.50
" 58	"	"	"	"	100.75	161.98
" 59	"	"	"	"	112.87	177.76
" 60	"	"	1.05	1.05	157.88	240.09
" 61	"	"	1.71	1.71	175.05	275.68
" 62	"	"	1.71	1.71	254.45	401.88
" 63	"	"	7.57	13.08	309.96	489.14
" 64	"	"	12.17	19.36	370.48	581.68
" 65	"	"	32.56	47.16	439.12	700.58
" 66	"	"	52.62	83.88	512.58	837.61
" 67	0.20	0.20	62.04	109.70	619.90	1,010.61
" 68	2.40	4.60	104.90	177.38	670.61	1,154.20

Notes:

1. All figures obtained from Annual Reports of B.E.A., C.E.A., and C.E.G.B.

2. The Electricity Supply industry was nationalised on April 1st, 1948 and the earliest national statistics available are those for the year ending 31st March, 1949.

Appendix D

Scale of Rental and Compensation Payments for Towers

The C.E.G.B. shall pay to the grantor:-

1. An annual rental for each tower with base dimensions over concrete at ground level of:

Under 15 ft. x 15 ft	5s.
15 ft. x 15 ft. but under 25 ft. x 25 ft.	9s. 6d.
25 ft. x 25 ft. but under 35 ft. x 35 ft.	12s. 6d.
35 ft. x 35 ft. but under 45 ft. x 45 ft.	19s.
45 ft. x 45 ft. and over	25s.

2. As compensation in respect of each tower which interferes with agriculture:

2.1 For each tower with base dimensions over concrete at ground level of:-	Erected on Arable land	Erected on Cultivated Grassland
	Per annum	
Under 8 ft. 6 in. x 8 ft. 6 in.	29s.	9s.
8 ft. 6 in. x 8 ft. 6 in. but under 12 ft. 6 in. x 12 ft. 6 in.	37s.	9s.
12 ft. 6 in. x 12 ft. 6 in. but under 17 ft. 6 in. x 17 ft. 6 in.	47s.	12s.
17 ft. 6 in. x 17 ft. 6 in. but under 22 ft. 6 in. x 22 ft. 6 in.	63s.	15s.
22 ft. 6 in. x 22 ft. 6 in. but under 30 ft. x 30 ft.	80s.	18s.
*30 ft. x 30 ft. but under 35 ft. x 35 ft.	97s.	18s.
35 ft. x 35 ft. but under 40 ft. x 40 ft.	127s.	18s.
40 ft. x 40 ft. but under 45 ft. x 45 ft.	147s.	21s.
45 ft. x 45 ft. but under 50 ft. x 50 ft.	187s.	21s.
50 ft. x 50 ft. but under 55 ft. x 55 ft.	233s.	27s.
55 ft. x 55 ft. and over	287s.	27s.

*Payments for towers of 30 ft. x 30 ft. and over have been settled on an interim basis since the towers of the CEGB's 400 kV lines have not been erected long enough for their effect to be properly appraised.

2.2 In any year in which the land is cultivated twice and more than one separate and distinct crop is taken off double compensation rates shall be paid.

2.3 In any year in which ploughing or other cultivations are performed by means of steam or other cable tackle double compensation rates shall be paid.

Provided that in any year in which both (b) and (c) operate treble compensation rates shall be paid.

2.4 When arable land is laid down to grass arable rates shall continue to be paid for the first two years but thereafter the land shall be treated as grass land until it is again ploughed.

2.5 The said sums shall be paid on the .... in each year the first payment being proportioned from the date of commencing the erection of the electric line.

2.6 The said compensation is intended to reimburse the grantor in respect of the following matters arising out of the existence of the completed towers in proper condition on the siad land but not further or otherwise, namely:-

(i) Loss of crops or of the power to cultivate or use the sites of the said towers or the land immediately adjoining those sites.

(ii) Interference with the work of cultivation of fields or meadows whereon the said towers are erected.

(iii) Labour required to keep the sites of the said towers or the land immediately adjoining the same free from weeds and undergrowth.

2.7 If during the continuance of this Agreement the grantor shall cease to occupy the said land or any part thereof and shall let the same or any part thereof the said annual sums continue to be paid to the grantor or as he shall in writing direct.

CHAPTER 51.

An Act to amend the law with respect to the supply of electricity. [15th December 1926.]

A.D. 1926

BE it enacted by the King's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

Power to lop trees and hedges obstructing electric lines.

34.—(1) Where any tree or hedge obstructs or interferes with the construction, maintenance, or working of any main transmission line or other electric line which is being constructed or is owned by any authorised undertakers, or will interfere with the maintenance or working of such a line, the authorised undertakers may give notice to the owner or occupier of the land on which the tree or hedge is growing requiring him to lop or cut it so as to prevent the obstruction or interference, subject to the payment to him by the authorised undertakers of the expenses reasonably incurred by him in complying with the notice:

Provided that, in any case where such a notice is served upon a person who, although the occupier of the land on which the tree or hedge is growing, is not the owner thereof, a copy of the notice shall also be served upon the owner thereof, if known.

(2) If within twenty-one days from the giving of such notice the requirements of the notice are not complied with, and neither the owner nor occupier of the land gives such a counter notice as is hereinafter mentioned, the authorised undertakers may cause the tree or hedge to be lopped or cut so as to prevent such obstruction or interference as aforesaid.

(3) If, within twenty-one days from the giving of such notice, the owner or occupier of the land on which the tree or hedge is growing gives a counter notice to the authorised undertakers objecting to the requirements of the notice, the matter shall, unless the counter notice is withdrawn, be referred to the Minister of Transport, who, after giving the parties an opportunity of being heard, may make such order as he thinks just, and any such order may empower the authorised undertakers (after giving such reasonable previous notice to any person by whom such counter notice was given of the commencement of the work as the order may direct) to cause the tree or hedge to be lopped or cut so as to prevent such obstruction or interference as aforesaid, and may determine any question as to what compensation (if any) and expenses are to be paid.

(4) The authorised undertakers shall issue instructions to their officers and servants with a view to securing that trees and hedges shall be lopped or cut in a woodmanlike manner and so as to do as little damage as may be to trees, fences, hedges, and growing crops, and shall cause the boughs lopped to be removed in accordance with the directions of the owner or occupier, and shall make good any damage done to the land.

(5) Any compensation or expenses payable to the owner or occupier by the authorised undertakers under this section shall be recoverable summarily as a civil debt.

(6) Where for the purpose of the construction or maintenance of a transmission line it is necessary to fell any trees, this section shall apply to the felling of trees in like manner as it applies to the lopping of trees.

(7) This section shall apply to main transmission lines owned or to be constructed by the Board in like manner as it applies to lines owned or to be constructed by authorised undertakers.

FIRST COMMISSIONING OF PRIMARY GRID 400 kV AND 275 kV SUBSTATIONS

1954	1955	1956	1957	1958	1959	1960	1961
West Melton	Nil	Elstree	Carrington Iver Monk Fryston	Melksham Rochdale Skelton Grange West Weybridge	Connah's Quay Fleet Hams Hall Harker Penwortham	Barking Brinsworth Bustleholm Corby Elland Exeter Feckenham Finchley Lovedean Needham Northfleet West Penn Pyle Sundon Taunton Waltham Cross Whitson	Keadby Kirkby Lackenby Norton

FIRST COMMISSIONING OF PRIMARY GRID 400 kV AND 275 kV SUBSTATIONS (Cont)

Appendix F. (cont.)

1962	1963	1964	1965	1966	1967	1968	1969
Canterbury	Norton Lees	Aldwarke	Beddington	Bramford	Bredbury	Bradford West	
Chessington		Cowbridge	Bolney	Chesterfield	Burwell	Cellarhead	
Hartmoor		Grangetown	Capenhurst	Enderby	Bushbury	Creyke Beck	
Stalybridge		Mill Hill	Ealing	Frodsham	Cowley	Daines	
West Boldon		Thorpe Marsh	Iron Acton	Kitwell	East Claydon	Hawthorn Pitt	
		Walham	Laleham	Osbaldwick	Kearsley	Legacy	
			Rye House	Macclesfield	Mannington	New Cross	
			Thurcroft	Rainhill	Ninfield	Sheffield City	
				Spennymoor	Pelham	South	
				St. John's Wood	Walpole	Manchester	
				Tottenham	Watford	Tynemouth	
				Warley		Willesden	
						Wimbledon	

Notes:- 1. Data abstracted from B.E.A., C.E.A. and C.E.G.B. Annual Reports and C.E.G.B. Statistical Yearbooks.

2. Substations adjoining power stations not included in this schedule.

CHAPTER 48

An Act to provide for the dissolution of the Central Electricity Authority and the establishment of a Central Electricity Generating Board and an Electricity Council, and for the transfer of functions of the said Authority to that Board or Council or to the Minister of Power; to make further provision as to other matters relating to the supply of electricity; and for purposes connected with the matters aforesaid.

[17th July, 1957]

BE it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

Preservation of amenity.

37. In formulating or considering any proposals relating to the functions of the Generating Board or of any of the Area Boards (including any such general programme as is mentioned in subsection (4) of section eight of this Act), the Board in question, the Electricity Council and the Minister, having regard to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest, and of protecting buildings and other objects of architectural or historic interest, shall each take into account any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, buildings or objects.

Appendix H

ELIZABETH II

1968 CHAPTER 41

An Act to enlarge the functions of the Commission established under the National Parks and Access to the Countryside Act 1949, to confer new powers on local authorities and other bodies for the conservation and enhancement of natural beauty and for the benefit of those resorting to the countryside and to make other provision for the matters dealt with in the Act of 1949 and generally as respects the countryside, and to amend the law about trees and woodlands, and footpaths and bridleways, and other public paths.

[3rd July 1968]

BE IT ENACTED by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

Conservation of natural beauty.

11. In the exercise of their functions relating to land under any enactment every Minister, government department and public body shall have regard to the desirability of conserving the natural beauty and amenity of the countryside.

Appendix I

DEVELOPMENT PLAN ZONING AND FORMER LAND USE OF PRIMARY TRANSMISSION SUBSTATION SITES

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
ABHAM, Devon 400/132 kV	1" O.S. 188 M.R.774647	9. 2.65	White land.	Agricultural
ADDERLEY PARK, Birmingham 275/132 kV Switch'se	1" O.S. 131 M.R.092869	23. 9.65 29.1.68	Industrial.	Derelict land
ALDWARKE W. Riding Yorks. 275/132 kV	1" O.S. M.R.			
ALVERDISCOTT Devon 400/132 kV	1" O.S. 163 M.R.502252	29.1.68	White land.	Agricultural
BARKING, Essex 275 kV Switch'se	1" O.S. 161 M.R.468824	26. 3.63 19.11.63	Area for deposit of Waste Materials or Refuse	Derelict land
BEDDINGTON, London 275/132 kV	1" O.S. 170 M.R.303655	4. 1.63	Sewage Disposal	Waste land
BERKSWELL, Warwicks 275/132 kV	1" O.S. 131 M.R.265765	22. 6.67	White land Proposed Coventry Green Belt.	Pasture
BIRKENHEAD, Ches. 275/132 kV	1" O.S. 100 M.R.291861	29.12.64	Clay working, part light industrial	Worked out brickfield
BISHOP'S WOOD Worcs. 275/132 kV	1" O.S. 130 M.R.835683	27. 4.66	White land.	Woodland
BOLNEY East Sussex 400/275/132 kV	1" O.S. 182 M.R.239210	29. 9.64	White land.	Arable and Pasture
BRADFORD WEST, W. Riding Yorks. 275/132 kV	1" O.S. 96 M.R.090349	27. 3.63 26. 3.64 6. 9.67	White land. Proposed Green Belt.	Pasture
BRAINTREE, Essex 400/132 kV	1" O.S. 149 M.R.774217	7. 1.66	White land.	Arable

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
BRAMFORD, Suffolk 400/132 kV	1" O.S. 149 M.R.100459	25. 9.61	White land	Arable and Pasture
BRAMLEY, Hants. 400/132 kV	1" O.S. 169 M.R.644599	13. 1.65	White land	Woodland
BREDBURY, Ches. 275/132 kV	1" O.S. 101 M.R.907915	23. 6.64	White land. Proposed North Cheshire Green Belt.	Pasture
BRIDGWATER, Somerset 275/132 kV	1" O.S. 165 M.R.323358	16.11.65	White land	Pasture
BRIMSDOWN, Middlesex 275/132 kV	1" O.S. 161 M.R.356979	10.11.58 13. 4.59 -. 8.60	Industrial. Statutory Undertaker - electricity	In disused part of Power Station Site
BRINSWORTH, W. Riding Yorks. 275 kV	1" O.S. 103 M.R.434898	22. 3.60 6. 7.60 15. 5.63	White land Statutory Undertaking - Electricity Green Belt	In disused part of Power Station site
BURWELL, Cambs. 400/132 kV	1" O.S. 135 M.R.579672	3. 5.63	White land.	Arable
BUSHBURY, Staffs. 275/132 kV	1" O.S. 119 M.R.922042	3. 5.55 27. 4.65	White land Proposed West Midlands Green Belt	Pasture and Arable
BUSTLEHOLM, Staffs. 275/132 kV	1" O.S. 131 M.R.027950	16. 8.61	White land	Pasture
CANTERBURY, Kent. 400/275 kV	1" O.S. 173 M.R.160595	19. 1.60 19.11.65 26. 7.67	White land	Disused wet gravel pits
CAPENHURST, Cheshire 400/132 kV	1" O.S. 100 M.R.368750	22. 2.63	Part White land and Part U.K.A.E.A. Proposed West Cheshire Green Belt.	Pasture
CARRINGTON Cheshire 400 kV/275 kV	1" O.S. 101 M.R.747927	16. 4.53 28. 5.64	White land. Statutory Undertaking - Electricity	In disused part of Power Station site

Appendix I (Contd.)

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
CELLARHEAD, Staffs. 400/132 kV	1" O.S. 110 M.R.943492	10. 8.64 27. 1.66	White land Proposed North Staff's Green Belt	Arable and Pasture
CHESSINGTON, Surrey. 275/132 kV	1" O.S. 170 M.R.169619	7. 3.60	White land Metropolitan Green Belt	Pasture and Woodland
CHESTERFIELD, Derbyshire 275/132 kV	1" O.S. 112 M.R.409699	18. 4.57 19.10.61	White land	Arable and Pasture
CHICKERELL, Dorset 400/132 kV	1" O.S. 178 M.R.656806	30.10.64 26.10.66 8. 6.67	White land	Pasture
CILFYNYDD, Glam. 400/132 kV	1" O.S. 154 M.R.100938	28. 4.65	White land	Poor Pasture
CORBY, Northants. 275/132 kV	1" O.S. M.R.			
COVENTRY, Warwicks. 275/132 kV	1" O.S. 132 M.R.365843	28. 3.62 27. 7.66	White land	Refuse tip
COWBRIDGE, Glam. 275/132 kV	1" O.S. 154 M.R.024775	19. 9.62 4.10.62	White land	Pasture
COWLEY, Oxon. 400/132 kV	1" O.S. 158 M.R.560016	15. 5.63	White land Proposed Oxford Green Belt	Pasture and Woodland
CREWE, Cheshire 400/132	1" O.S. 110 M.R.679566	11.10.63	Part residential, part industrial	Pasture
CREYKE BECK, E. Riding Yorks. 275/132 kV	1" O.S. 99 M.R.044350	9.10.52 23.12.63	White land	Arable
DAINES, Cheshire 400/132 kV	1" O.S. 101 M.R.750928	17. 2.53 28. 5.64	White land Green Belt	Pasture

Appendix I (Contd.)

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
DEESIDE, Flints. 400/275 kV	1" O.S. 109 M.R.281709	18. 3.64	Area for deposit of refuse	Derelict land
EALING, London 132/66 kV Switch'se	1" O.S. 160 M.R. 184795	9. 6.61 16. 1.63	Statutory Undertaker C.E.G.B.	Cleared industrial Site
EAST CLAYDON, Bucks. 400/132 kV	1" O.S. 146 M.R.751258	23. 3.64	White land	Pasture
ELSTREE, Herts. 275/132 kV	1" O.S. 160 M.R.149969	12. 6.52 19. 6.62 12. 6.63	Metropolitan Green Belt White land	Agricultural
ENDERBY, Leics. 400/132 kV	1" O.S. 121 M.R.533005	21. 8.63 27. 1.64	White land	Pasture
EXETER, Devon. 275/132 kV	1" O.S. 176 M.R.009973	28.10.59 1. 3.60 11. 8.64	White land	Pasture
FECKENHAM, Worcs. 400/275/132 kV	1" O.S. 131 M.R.022614	30. 4.58 28. 2.66	White land. Proposed Green Belt	Pasture
FLEET, Hants. 400/275/132 kV	1" O.S. 169 M.R.731505	28. 3.56 13. 1.65 13.10.65	White land	Woodland
FRODSHAM, Cheshire 275/132 kV	1" O.S. 100 M.R.528793	22. 8.62	Area for deposit of refuse	Derelict land
GRANGETOWN N. Riding Yorks. 275/132 kV				
GRENDON, Northants. 400/132 kV	1" O.S. 133 M.R.869613	11. 5.66	White land	Pasture and Arable
GRIMSBY WEST, Lincs. 400/132 kV	1" O.S. 105 M.R.225092	5. 2.65	White land	Pasture, Arable and Woodland

Appendix I (Contd.)

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
HACKNEY, London 132/66 kV Switch'se	1" O.S. 161 M.R.356862	25. 6.66 12.12.66	Lee Valley Regional Park. Public Open Space	Public Park
HAMS HALL, Warwicks 400/275/132 kV	1" O.S. 131 M.R.194923	15. 1.57 1.11.66 31. 5.67	White land Proposed Green Belt	Pasture and Arable
HARKER, Cumberland 400/275/132 kV	1" O.S. 76 M.R.383612	30. 7.51 27. 6.66 3.10.66	White land.	Pasture and Arable
HARTMOOR, Co. Durham 275/132 kV				
HAWTHORN PITT Co. Durham 275/132 kV				
HEREFORD, Herefordshire 400/132 kV	1" O.S. 142 M.R.540380	31. 7.67	Ministry of Supply land.	Disused M. of S. land
HURST, Kent. 275/132 kV	1" O.S. 171 M.R.489730	25. 3.66	Metropolitan Green Belt	Pasture
INDIAN QUEENS, Cornwall 400/132 kV	1" O.S. 185 M.R.939592	18. 2.63 28. 3.66	White land. "China clay consultation area".	Water logged scrub Woodland
IRON ACTON, Glos. 275/132 kV	1" O.S. 156 M.R.668858	27. 9.62	White land. Proposed Green Belt	Pasture and Arable
IVER, Bucks. 275/132 kV	1" O.S. 160 M.R.042836	5.11.63	Green Belt	Pasture
KEADBY, Lincs. 400/275/132 kV	1" O.S. 104 M.R.824120	14. 8.64	White land.	Pasture
KEARSLEY, Lancs. 400/275 kV Switch'se	1" O.S. 101 M.R.764046	17. 9.56 13. 1.61	Proposed Green Belt. Partly Statutory undertakins (Sewerage Board and C.E.G.B.) and partly White land.	Pasture and Derelict land

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
KIRBY, Lancs. 400/275/132 kV	1" O.S. 100 M.R.438973	21. 5.57 21. 3.63	White land.	Pasture and Arable
KIRKSTALL, Leeds, Yorks. 275/132 kV	1" O.S. 96 M.R.368244	8.11.65 12. 8.66	Public Open Space	Public open space
KITWELL, Worcs. 275/132 kV	1" O.S. 131 M.R.992814	9.10.62 11. 6.63	White land Part in proposed Green Belt.	Pasture
LACKENBY, N. Riding Yorks. 275/66 kV	1" O.S. 86 M.R.562195	16. 9.58	Industry	Poor quality pasture
LALEHAM, Middx. 275/132 kV	1" O.S. 160 M.R.064706	7. 4.61	Water Works land	Derelict land.
LANDULPH, Cornwall 400/132 kV	1" O.S. 187 M.R.409629	17. 9.62	White land	Pasture and Arable
LEGACY, Denbigh. 400/132 kV	1" O.S. 109 M.R.294485	12.11.64	Part White land and Part County Council Small-holding	Pasture and Arable
LISTER DRIVE, Liverpool, Lancs. 275 kV Switch'se	1" O.S. 100 M.R.386917	3. 4.63 6. 1.66 4. 5.67	Industrial	Derelict Industrial land
LOVEDEAN, Hants. 400/275/132 kV	1" O.S. 181 M.R.676135	23. 5.61 22.11.63	White land Hampshire Coast Green Belt	Pasture and Arable
LYDD, Kent 275 AC/DC Converter	1" O.S. 184 M.R.031200	1. 7.59	White land	Shingle beach and Foreshore
MACCLESFIELD, Cheshire 275/132 kV	1" O.S. 110 M.R.918746	24.10.51 18.12.61 9. 5.63	Industrial	Derelict industrial land
MANNINGTON, Dorset 400/132 kV	1" O.S. 179 M.R.075052	16. 8.63	White land	Heath land

Appendix I (Contd.)

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
MELKSHAM, Wilts. 400/275/132 kV	1" O.S. 157 M.R.897662	25.10.54 25. 4.56 19. 7.65	White land	Pasture and Arable
MILL HILL, Middx. 275/132 kV	1" O.S. 160 M.R.241926	26. 5.61	War Department land Metropolitan Green Belt	Disused Anti aircraft gun site.
MONK FRYSTON, W. Riding Yorks. 400/275/132 kV	1" O.S. 97 M.R.485292	17.10.52 24.10.60	White land Green Belt	Pasture and Arable
NECHELLS, Birmingham 275/132 kV	1" O.S. 131 M.R.098898	11. 3.65	Industrial	Disused sewage works
NEW CROSS, London 275/66 kV Switch'se	1" O.S. 160 M.R.346778			
NINFIELD, E. Sussex 400/132 kV	1" O.S. 183 M.R.717117	25. 7.63 13. 5.64	White land	Pasture
NORTHFLEET, Kent 275/132 kV	1" O.S. 171 M.R.609729	29. 3.56 24. 1.64	Surface working of chalk Metropolitan Green Belt	Pasture and Arable
NORTON, Co. Durham 275/132 kV	1" O.S. 85 M.R.412220	18. 8.65 22. 1.59	White land	Pasture
NORTON LEES, W. Riding Yorks. 275/132 kV				
NORWICH, Norfolk 400/132 kV	1" O.S. 126 M.R.218024	20. 5.65	White land Proposed Green Belt.	Pasture
NURSLING, Hants. 400/132 kV	1" O.S. 180 M.R.362162	10. 6.63	Gravel working Proposed Hampshire Coast Green Belt	Disused gravel working
OCKER HILL, Warwicks. 275 kV	1" O.S. 131 M.R.979938	30. 1.52 21. 8.57	Industrial Statutory undertaker - C.E.G.B.	Derelict land

Appendix I (Contd.)

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
OLDBURY, Worcs. 275/132 kV	1" O.S. 130 M.R.985890	23. 6.65 4. 1.66	Part area for deposit of refuse, part industrial, part private open space.	Derelict land and wet worked out clay pit
OSBALDWICK, E. Riding Yorks. 275/132 kV	1" O.S. 97 M.R.641517	28. 2.63	White land Proposed Green Belt	Pasture and Arable
PELHAM, Essex. 400/132 kV	1" O.S. 148 M.R.457285	8. 5.63 24. 6.65	White land	Pasture and Arable
PENN, Staffs. 275/132 kV	1" O.S. 130 M.R.860954	19. 6.56	White land Proposed Green Belt	Pasture
PENTIR, Caerns. 400/132 kV	1" O.S. 106 M.R.559678	31. 7.62	Green Belt	Pasture and Woodland
PENWORTHAM, Lancs. 400/275/132 kV	1" O.S. 94 M.R.501279	18. 2.53 12. 8.66	White land	Pasture
PYLE, Glam. 275 kV 132 kV	1" O.S. 153 M.R.828829	27. 5.54 7. 1.57 14. 6.65	White land	Pasture
RAINHILL, Lancs. 400/132 kV	1" O.S. 100 M.R.509918	30.10.63	Mineral workings	Disused gravel pits
RAYLEIGH, Essex 400/275/132 kV	1" O.S. 162 M.R.780915	3. 2.65 4.12.65	White land Proposed Grren Belt	Pasture mainly Arable
REDBRIDGE, Essex 275/132 kV	1" O.S. 161 M.R.422872	28. 3.66	White land Metropolitan Green Belt	Pasture
ROCHDALE, Lancs. 275/132 kV	1" O.S. 101 M.R.871167	10. 3.54 4. 5.66	White land	Pasture
SEVEN SPRINGS, Glos. 400/132 kV	1" O.S. 144 M.R.982163	18. 7.66	White land Area of Outstanding Natural Beauty (Cotswolds)	Arable mainly woodland

Appendix I (Contd.)

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
SHEFFIELD CITY, Sheffield 275/132 kV				
SKELTON GRANGE, Leeds 275/132 kV	1" O.S. 96 M.R.332313	7. 9.66 4.10.66	Area for C.E.G.B. purposes (Adjoining Power Station)	Pasture
SOUTH MANCHESTER, Cheshire 275/132 kV	1" O.S. 101 M.R.817916	12.63 3. 9.64 3. 3.65	White land (Part in Cheshire) Public open space (Part in Manchester)	Derelict land formerly domestic refuse tip
SPENNYMOOR, Co. Durham 275/132 kV	1" O.S. 85 M.R.288345	26.10.62	White land	Pasture
STALYBRIDGE, Lancs. 275/132 kV	1" O.S. 101 M.R.974997	6.11.58	Industry	Pasture
STELLA WEST, Northumb'ld. 275 kV	1" O.S. 78 M.R.171646	12. 1.51	Colliery use, or surface winning of coal	Pasture
ST. JOHNS WOOD London 275/66 kV Switch'se	1" O.S. 160 M.R.270825	61 62 64	Statutory undertaker - Electricity	On site of former Power Station
SUNDON, Beds. 400/275/132 kV	1" O.S. 147 M.R.032272	24. 9.63 15.10.65	White land	Arable
SWANSEA NORTH, Glam. 400/275/132 kV	1" O.S. 153 M.R.645002	20. 8.65	White land	Poor quality Pasture
TAUNTON, Somerset 275/132 kV				
TEMPLEBOROUGH, W. Riding Yorks. 275/132 kV				
THORPE MARSH, W. Riding Yorks 400/275 kV	1" O.S. 103 M.R.095607	16. 4.58 20. 7.64	Public Authority - Land drainage (Washlands)	Water meadows

Appendix I (Contd.)

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
THURCROFT, W. Riding Yorks. 275/132 kV				
TINSLEY PARK, W. Riding Yorks. 275/132 kV				
TOTTENHAM, Middx. 275/132 kV	1" O.S. 161 N.R.353912	14.10.57 17. 8.62 6. 9.62	Residential	Residential
TYNEMOUTH, N'umberland 275/132 kV	1" O.S. 78 N.R.319703	25. 3.64	Part White land, and part Surface area for Colliery purposes	Pasture
WALHAM, Gloucester 400/275/132 kV	1" O.S. 143 N.R.828202	11. 8.61 27. 9.62 17. 9.64	White land. Wash land area of River Severn	Water meadows
WALPOLE, Norfolk 400/132 kV	1" O.S. 124 N.R.486163	13. 8.62	White land	Arable
WALTHAM CROSS, Essex 275/132 kV	1" O.S. 161 N.R.375036	2. 6.61	Gravel extraction. Metropolitan Green Belt. Lea Valley Regional Park	Disused wet gravel pits
WARLEY, Essex 275/132 kV	1" O.S. 161 N.R.596863	16. 9.63	Metropolitan Green Belt	Pasture and Arable
WATFORD, Middx. 275/132 kV	1" O.S. 160 N.R.105950	12. 6.63 14. 1.64	Metropolitan Green Belt	Derelict Pasture
WEST BOLDON, Co. Durham 275/66 kV	1" O.S. 78 N.R.340607	26. 3.59 30. 7.59	White land South Tyneside Green Belt	Pasture and Arable
WEST MELTON, W. Riding Yorks. 275/132 kV	1" O.S. 103 N.R.413007	7.11.49 7. 2.67	White land	Pasture and Arable
WEST THURROCK, Essex 400 kV	1" O.S.161/171	12. 8.57 29. 1.58 29.10.65	Industrial	Derelict

Appendix I (Contd.)

Substation	Location	Date of Consent/S	D.P. Zoning	Land Use
WEST WEYBRIDGE, Surrey 275/132 kV	1" O.S. 170 M.R.058625	18. 5.55 23.10.64 14. 6.66	Statutory Allotments. Metropolitan Green Belt	Allotments
WHITEGATE, Lancs. 275/132 kV	1" O.S. 101 M.R.871035	15.12.65	Power Station site. Statutory undertaker - Electricity	In disused part of Power Station site
WHITSON, Monmouthshire 275 kV Switch'se	1" O.S. 155 M.R.371855	21. 6.60 18. 7.60	White land. Proposed Green Belt	Pasture and Arable
WILLENHALL, Staffs. 275 kV	1" O.S. 131 M.R.969978	19. 4.67 26. 5.67	Industrial	Pasture
WILLESDEN, London 275/132 kV	1" O.S. 160 M.R.209832	13. 4.64 10. 7.64 16.11.65	Statutory undertaker - Electricity	In disused part of Power Station Site
WILLINGTON, Derby 400/275 kV	1" O.S. 120 M.R.307286	17.12.62 10. 2.65	White land.	Pasture and Arable
WIMBLEDON, London 275/132 kV Switch'se	1" O.S. 170 M.R.261718	20. 5.64	Statutory Undertaker - Electricity	In disused part of Power Station site
WYMONDLEY, Herts. 400/132 kV	1" O.S. 147 M.R.206269	9.10.52	White land. Proposed extension to Metropolitan Green Belt	Pasture and Arable

Notes: 1. This list only includes Primary substation sites for switching or transforming at 400 kV and 275 kV.

2. This list does not include substations within the boundary of a power station.

3. Data obtained from C.E.G.B. publications, Local Planning Authorities and personal observation.

3rd December, 1968
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Appendix J

Schedule of Areas of Substation Sites

Berkswell, Warwickshire.	275/132 kV	M.R.265765	41.78 acres
Birkenhead, Cheshire.	275/132 kV	M.R.291861	41.00 acres
Bishops Wood, Worcestershire.	275/132 kV	M.R.835683	41.30 acres
Braintree, Essex.	400/132 kV	M.R.774217	45.52 acres
Bramford, Suffolk.	400/132 kV	M.R.100459	32.88 acres
Bredbury, Cheshire.	275/132 kV	M.R.907915	38.00 acres
Bridgwater, Somerset.	275/132 kV	M.R.323358	33.28 acres
Cellarhead, Staffordshire.	400/132 kV	M.R.943492	68.52 acres
Chickerell, Dorset.	400/132 kV	M.R.656806	42.60 acres
Cowley, Oxfordshire.	400/132 kV	M.R.560016	54.36 acres
Creyke Beck, Yorkshire.	275/132 kV	M.R.044350	16.94 acres
Indian Queens, Cornwall.	400/132 kV	M.R.939592	23.30 acres
Iver, Buckinghamshire.	275/132 kV	M.R.042836	38.38 acres
Legacy, Denbighshire.	400/132 kV	M.R.294485	28.00 acres
Lovedean, Hampshire.	400/132 kV	M.R.676135	42.28 acres
Mannington, Dorset.	400/132 kV	M.R.075052	51.20 acres
Mill Hill, Middlesex.	275/132 kV	M.R.241926	50.00 acres
Mop End, Buckinghamshire.	400/132 kV	M.R.927968	52.80 acres
Ninfield, East Sussex.	400/132 kV	M.R.717117	42.30 acres
Norton, Durham.	275/132 kV	M.R.412220	41.90 acres
Norwich, Norfolk.	400/132 kV	M.R.218024	70.34 acres
Osbaldwick, Yorkshire.	275/132 kV	M.R.641517	28.00 acres
Pentir, Caernarvonshire.	400/132 kV	M.R.559678	27.00 acres
Swansea North, Glamorganshire.	400/132 kV	M.R.645002	55.76 acres
West Boldon, Durham.	275/66 kV	M.R.340607	32.79 acres
Wymondley, Hertfordshire.	400/132 kV	M.R.206269	78.28 acres

CHAPTER 56.

An Act for facilitating the regulation and improvement of Commons, and for amending the Acts relating to the Inclosure of Commons. [11th August 1876.]

A.D. 1876.

"Regulation of common" includes adjustment of rights and improvement.

3. A provisional order for the regulation of a common may provide, generally or otherwise, for the adjustment of rights in respect of such common, and for the improvement of such common, or for either of such purposes, or for any of the things by this Act comprised under the expression "adjustment of rights" or "improvement of a common," or may state that all or any of such subjects are to be provided for in the proceedings subsequent to the confirmation of the provisional order by Parliament.

Explanation of improvement.

5. The improvement of a common comprises for the purposes of this Act all or any of the following things; that is to say,

(1.) The draining, manuring, or levelling the common; and

(2.) The planting trees on parts of such common, or in any other way improving or adding to the beauty of the common; and

(3.) The making or causing to be made byelaws and regulations for the prevention of or protection from nuisances or for keeping order on the common; and

(4.) The general management of such common.

(5.) The appointment from time to time of conservators of the common for the purposes aforesaid.

Appendix L

CHAPTER 97

An Act to make provision for National Parks and the establishment of a National Parks Commission; to confer on the Nature Conservancy and local authorities powers for the establishment and maintenance of nature reserves; to make further provision for the recording, creation, maintenance and improvement of public paths and for securing access to open country, and to amend the law relating to rights of way; to confer further powers for preserving and enhancing natural beauty; and for matters connected with the purposes aforesaid. [16th December 1949.]

89.—(1) A local planning authority may plant trees on land in their area for the purpose of preserving or enhancing the natural beauty thereof. Planting of trees and treatment of derelict land.

(2) For the purpose of restoring or improving the appearance of derelict land in their area which in the opinion of the authority is in any way unsightly, a local planning authority may—

(*a*) plant trees, or

(*b*) carry out such work or do such other things as appear to them expedient for that purpose.

(3) The powers conferred by this section may be exercised by an authority either on land belonging to them or with the consent of all persons interested therein on other land; and in relation to such other land the said powers shall include power to make arrangements whereby the planting or work is carried out, on such terms as may be provided under the arrangements, by a person other than the authority.

(4) The powers conferred by the foregoing provisions of this section do not, as respects any land, include power to do anything which the council of any county, county borough or county district are or can be authorised to do as respects that land by any enactment not contained in this Act; and nothing in the said provisions shall authorise the doing of anything in contravention of any prohibition or restriction having effect under any enactment or rule of law.

(5) A local planning authority may acquire land compulsorily for the purpose of any of their functions under this section.

(6) Where a local planning authority exercise their powers under the foregoing provisions of this section on land not belonging to the authority, the management of the land, so far as relates to anything done by the authority, may be undertaken either by the authority or by a person interested in the land, as may be agreed between the authority and the persons so interested, and on such terms as may be so agreed.

7 & 8 ELIZ. 2 *Highways Act*, 1959 CH. 25

CHAPTER 25

An Act to consolidate with amendments certain enactments relating to highways, streets and bridges in England and Wales, including certain enactments commonly contained in local Acts, and to make consequential amendments of the common law.

[30th April, 1959]

BE it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

Dual carriageways and roundabouts.

65.—(1) A highway authority may, in relation to a highway maintainable at the public expense by them, being a highway which consists of or comprises a made-up carriageway, construct and maintain works in that carriageway—

(*a*) along any length of the highway, for separating a part of the carriageway which is to be used by traffic moving in one direction from a part of the carriageway which is to be used (whether at all times or at particular times only) by traffic moving in the other direction;

(*b*) at cross roads or other junctions, for regulating the movement of traffic.

(2) The powers conferred by the foregoing subsection shall include power to light any such works as aforesaid, to pave, grass or otherwise cover them or any part of them, to erect pillars, walls, rails or fences on, around or across them or any part of them, and to plant on them trees, shrubs and other vegetation either for ornament or in the interests of safety.

Trees, shrubs and verges

Powers of highway and local authorities to plant trees, lay out grass verges, etc.

82.—(1) Subject to the provisions of this section, a highway authority may, in a highway maintainable at the public expense by them, plant trees and shrubs and lay out grass verges, and may erect and maintain guards or fences and otherwise do anything expedient for the maintenance or protection of trees, shrubs and grass verges planted or laid out by them under this subsection.

Extension of powers of highway and local authorities to plant and protect trees in highways etc.

5.—(1) The following powers conferred on a highway authority by subsections (1) and (2) of section eighty-two of the principal Act, that is to say—

(*a*) the power to maintain and protect trees, shrubs and grass verges planted by the authority in a highway maintainable by them or in other land mentioned in the said subsection (2); and

(*b*) the power to alter or remove any such verge and any thing provided by the authority for the maintenance or protection of trees, shrubs or verges so planted by them,

shall be exercisable in relation to, and to things provided for the maintenance or protection of, trees, shrubs or verges whether or not they were provided or planted by the highway authority; and subsections (3) and (4) of that section (which provide for the exercise by the other authorities there mentioned of the powers conferred on a highway authority by the said subsection (1)) shall have effect accordingly.

(2) The following amendments consequential on the provisions of the foregoing subsection shall be made in the said subsection (1), that is to say—

(*a*) for the words " by them under this subsection " in both places where they occur there shall be substituted the words " , whether or not by them, in such a highway "; and

(*b*) for the words from " provided " onwards there shall be substituted the words " provided, whether or not by them, for the maintenance or protection of any tree, shrub or verge in such a highway ".

(3) Any reference in the said section eighty-two as amended by the last foregoing subsection to trees or shrubs shall include a reference to plants of any description; and accordingly the following subsection shall be inserted at the end of that section:—

" (8) References in this section to trees or shrubs shall be construed as including references to plants of any description."

Cutting or felling of dangerous trees etc. near roads or footpaths.

10.—(1) Where it appears to the appropriate authority for any highway, or for any other road or footpath to which the public has access,—

(*a*) that any hedge, tree, or shrub is dead, diseased, damaged or insecurely rooted; and

(*b*) that by reason of its condition it, or part of it, is likely to cause danger by falling on the highway, road or footpath;

the authority may, by notice either to the owner of the hedge, tree or shrub or to the occupier of the land on which it is situated, require him within fourteen days from the date of service of the notice so to cut or fell it as to remove the likelihood of danger.

(2) Subsections (2) to (4) of section one hundred and thirty-four of the principal Act (which relate to the interpretation of that section and to appeals from, and the enforcement of, notices under subsection (1) of that section requiring the cutting of vegetation which overhangs roads and footpaths) shall have effect as if references to that section and subsection (1) of that section included references to the foregoing subsection; and section two hundred and fifty-six of the principal Act (which confers powers of entry) shall have effect for the purposes of this section as if this section were a provision to which that section applies and as if the purposes mentioned in subsection (1) of that section included the purpose of ascertaining whether any hedge, tree or shrub is dead, diseased, damaged or insecurely rooted.

ELIZABETH II

1967 CHAPTER 69

An Act to make further provision for the protection and improvement of buildings of architectural or historic interest and of the character of areas of such interest; for the preservation and planting of trees; and for the orderly disposal of disused vehicles and equipment and other rubbish. [27th July 1967]

BE IT ENACTED by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

PART II

PRESERVATION AND PLANTING OF TREES

Duty of planning authority to provide for planting of trees.

12.—(1) It shall be the duty of the local planning authority to ensure, wherever it is appropriate, that, in granting planning permission for any development under the Planning Act or the Scottish Planning Act, as the case may be, adequate provision is made, by the imposition of conditions, for the preservation or planting of trees and to make such tree preservation orders under that Act as appear to that authority to be necessary in connection with the grant of such permission (whether for giving effect to such conditions or otherwise).

(2) A tree preservation order may be made so as to apply, in relation to trees to be planted pursuant to any such conditions, as from the time when those trees are planted.

Appendix P.

Schedule of printed sources concerning the landscaping of the Generating Board's primary grid substations:-

Abham	Power News	July 1967
Birkenhead	Birkenhead News	2. 6.65
	" "	5. 6.65
	Liverpool Echo	2.10.65
	Birkenhead News	9.10.65
	Midland Region News	Nov. 1965
Bolney	Span	Feb. 1965
Bredbury	County Express	10. 9.64
	Stockport Express	10. 9.64
	Stockport Advertiser	10. 9.64
	North Cheshire Herald	11. 9.64
	The Guardian	6.11.64
	Times	9.11.64
	Estates Gazette	14.11.64
Burton Green	Coventry Evening Telegraph	5. 5.65
	" " "	10. 9.65
	Birmingham Post	20.10.66
Canterbury	Kentish Gazette & Canterbury Press	28.10.66
	Kent Herald	2.11.66
	Kentish Express	4.11.66
	" Gazette	4.11.66
	Kent Messenger	4.11.66
	London Evening News	5.11.66
	" " "	12.11.66
	" " "	3.12.66
	Times	20. 4.67
	Kentish Gazette	21. 4.67
	London Evening News	24. 4.67
	Kent Herald	9. 8.67
Chickerell	Dorset Evening Echo	4. 5.66
	" " "	11. 5.66
	Power News	Sept.1966
	" "	July,1967
Coventry	Coventry Evening Telegraph	5. 5.65
	Power News	August,1968
Enderby	Power News	April,1964
	" "	Aug. 1968
Exeter	Express and Echo	31. 1.66
	Power News	July,1967
Fleet	Farnham Herald	16. 7.65
	Reading Mercury	16.10.65
	Farnham Herald	28.10.66

Grendon	Northamptonshire Evening Telegraph	14.11.64
	Northamptonshire Mercury & Herald	19.11.64
	Northamptonshire Evening Telegraph	20.11.64
	Kettering Leader	27.11.64
	" "	4.12.64
	Northampton Cronicle & Echo	3. 3.65
Hurst	Bexley Heath Observer	21. 1.66
	" " "	30. 9.66
	London Evening News	4.10.66
Kearsley	Bolton Evening News	19. 2.65
Kitwell	C.E.G.B. Press Statement	9. 6.64
	Birmingham Post	22. 2.64
	" Mail	10. 6.64
	" Post	10. 6.64
	Midlands Power	July, 1964
	Power News	July, 1964
	Power News	Aug. 1968
Legacy	The Liverpool Echo	3. 9.64
	Liverpool Daily Post	16.11.64
Ninfield	Span	Feb. 1965
	Bexhill Observer	28. 8.65
	Electricity	April, 1965
	Power News	Jan. 1967
Oldbury	Sunday Mercury	14. 8.66
Penwortham	Lancashire Evening Post	9. 8.66
	Electrical Review	26. 8.66
	The Estates Gazette	3. 9.66
Rayleigh	Southend Standard	22. 6.67
South Bucks	Reading Evening Post	25. 8.67
	The Guardian	25. 8.67
South Manchester	Wythenshaw Express	24.10.68
Wymondley	Times	29. 9.65
	Daily Telegraph	29. 9.65
	The Guardian	4.10.65
	The Guardian	6. 1.67
	Hitchin Pictorial	18. 1.67
	Hertfordshire Express	21. 9.67
	Hitchin Pictorial	22. 9.67

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1.1 For the Central Electricity Generating Board.

Mr. P.B. Jones, B.Sc., C.Eng., A.M.I.E.E.	- Planning Department, C.E.G.B., H.Q.
Mr. H.L. Mann, A.M.C.T., C.Eng., A.M.I.E.E.	- Project Engineer, Transmission Project Group, C.E.G.B.
Mr. K. Speke, A.M.C.T., C. Eng., A.M.I.E.E.	- Ass. Regional Transmission Maintenance Engineer, N.W. Region, C.E.G.B.
Mr. A.F. Clapham.	- Lands Officer, C.E.G.B., H.Q.

1.2 For the West Riding County Council

Mr. K.H. Tuson, C.Eng, M.I.E.E., M.A.C.E.	- Electrical Engineering Consultant.
Mr. L.N. Fraser, M.Eng., C.Eng., M.T.P.I., A.M.I.C.E.	- County Planning Officer.
Mr. D.J. Duckworth, A.I.L.A.	- Chief Planning Assistant.

1.3 For the Lancashire County Council

Mr. D. Tattersall, B.A., M.C.D., A.M.T.P.I.	- Senior Ass. Planning Officer.

1.4 Others

Mr. Barnes	- Council for the Preservation of Rural England.
Mr. Wilson	- Ramblers Association.
Mr. Rose	- Halifax Gliding Club
Mr. Preston-Jones	- Agent for Lord Savile
Mr. T.B. Sutcliffe	- Hardcastle Crags Preservation Society.

2. Ministry Reports

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Burnley Express	19.12.64
The Guardian	12. 3.65
Yorkshire Post	13. 3.65
The Guardian	30. 3.65
The Guardian	22. 4.65
Keighley News	22. 5.65
Yorkshire Post	24. 5.65
Daily Telegraph	26. 5.65
Lancashire Evening Telegraph	28. 5.65
Halifax Daily Courier	28. 5.65
Yorkshire Post	29. 5.65
Lancashire Evening Telegraph	13. 7.65
Yorkshire Evening Post	21. 7.65
Yorkshire Post	22. 7.65
Halifax Daily Courier	8. 9.65
Lancashire Evening Telegraph	13. 9.65
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Telegraph and Argus	18. 5.67
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Telegraph and Argus	19. 5.67
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Farmer's Guardian	5. 4.68
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Halifax Evening Courier	10. 5.68
Halifax Evening Courier	18. 5.68
Halifax Evening Courier	19. 7.68

Bradford Telegraph	2. 8.68
Halifax Evening Courier	8. 8.68
Bradford Telegraph	9. 8.68
Bradford Telegraph	20. 8.68
Bradford Telegraph	22. 8.68
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   1.1 By the Central Electricity Generating Board

   1.2 By Amersham Rural District Council

2. Written Proofs of Evidence at Public Inquiry 22. 8.67

   2.1 For the Central Electricity Generating Board

   Mr. P.J. Arnold B.Sc., M.I.E.E. - Assistant Transmission System Design Engineer

   Mr. J.B. Yates, M.I.E.E. - Senior Assistant Engineer, Transmission Project Group

   Mr. C.J. Cornes, B.Sc.,A.R.I.C.S. Q.A.L.A.S. - Principal Assistant, Estates Branch.

   Mr. G.A. Goulty, A.R.I.B.A., A.M.T.P.I.,A.I.L.A. - Principal Assistant Architect, Transmission Project Group

   2.2 For the Buckinghamshire County Council

   Mr. C. Knowles, A.R.I.C.S.,A.M.T.P.I.- Area Planning Officer

   2.3 For the Landowner

   Mr. R.P. Jarvis - Agent for the Trustees of the Hampden Settlement

   Mr. G.L.E. Eyles, F.R.I.C.S., F.A.I. - Senior Partner, Messrs. Hamnet Raffety & Co., Chartered Surveyors.

3. Ministry Reports following Public Inquiry 22. 8.67

3.1 Ministry of Power Ref. EL 72/16/A35 dated 30.11.67 concerning a compulsory purchase order for a proposed site for substation at Mop End. Inspector - Mr. French.

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3.3 Ministry of Power Ref. EL 82/16/A553 dated 18.12.67 concerning application for proposed overhead lines in the vicinity of the proposed substation at Mop End. Inspectors - Mr. French and Mr. Harcourt.

4. C.E.G.B. Report on Search for Alternative Sites 17. 6.68.

5. Written Proofs of Evidence at Reopening of Inquiry 12.12.68.

5.1 For the Central Electricity Generating Board

Mr. P.J. Arnold, B.Sc.,M.I.E.E.	- Assistant Transmission System Design Engineer
Mr. E.P.C. Watson, C.Eng.,M.I.E.E.	- Assistant Project Engineer, Transmission Project Group
Mr. G.A. Goulty, A.R.I.B.A., A.M.T.P.I.,A.I.L.A.	- Principal Assistant Architect Transmission Project Group
Mr. P.E. Woodley	- Principal Assistant, Wayleaves
Mr. C.J. Cornes, B.Sc.,A.R.I.C.S., Q.A.L.A.S.	- Principal Assistant, Estates Branch

5.2 For the Buckinghamshire County Council

Mr. R.C. Kenyon, F.R.I.C.S., M.T.P.I.	- Deputy County Planning Officer

6. Press Cuttings

Bucks Examiner	30. 6.67
Bucks Examiner	21. 7.67
Bucks Examiner	4. 8.67
Buckinghamshire Advertiser	8. 8.67
Buckinghamshire Advertiser	10. 8.67
Daily Telegraph	22. 8.67
The Guardian	23. 8.67
The Sun	23. 8.67
The Times	23. 8.67
Daily Telegraph	23. 8.67
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Reading Evening Post	25. 8.67
Daily Telegraph	26. 8.67

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Bucks Examiner	24. 5.68
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Bucks Examiner	7. 6.68
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The Times	1. 7.68
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<u>Chapter Ten</u>

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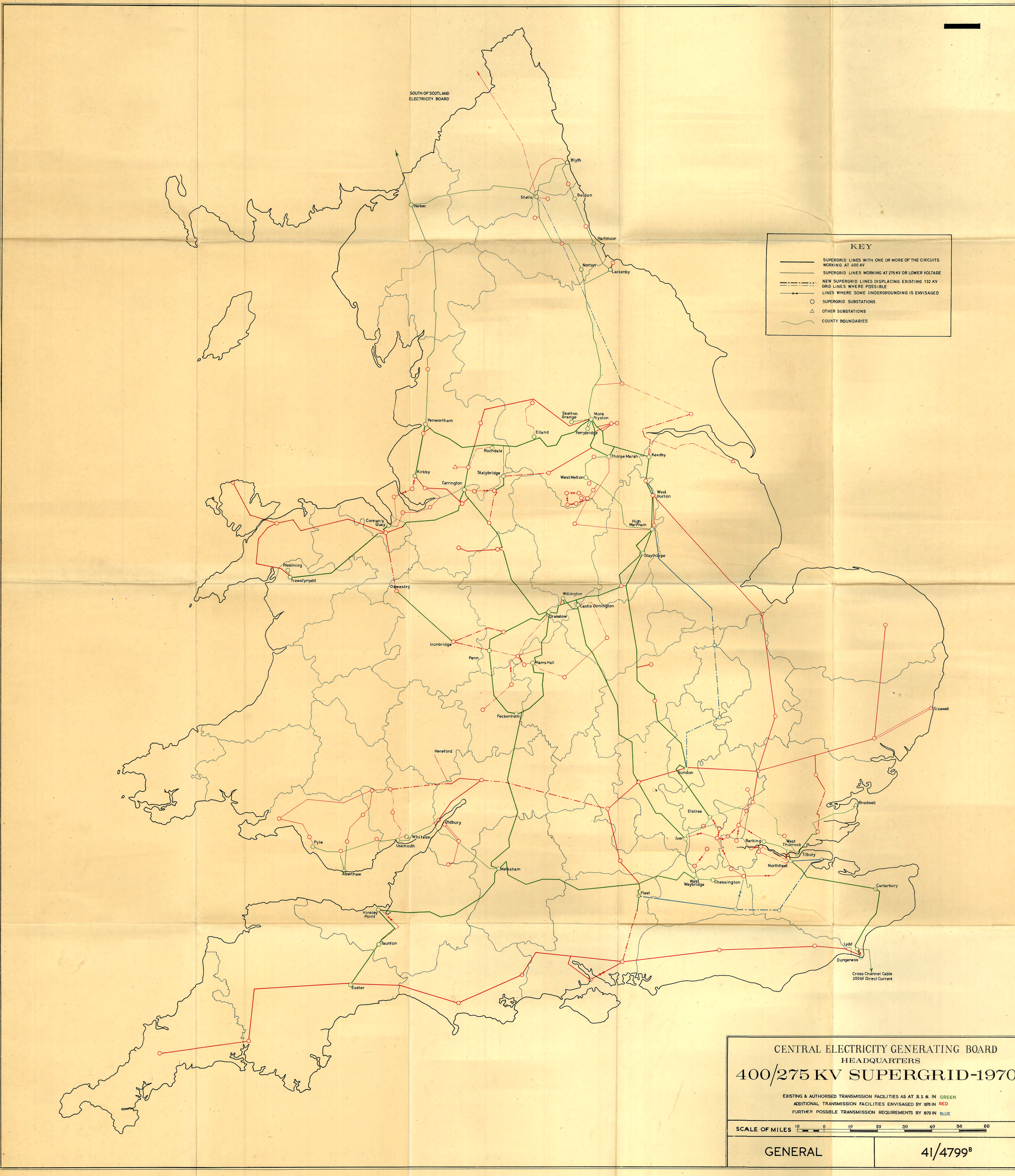
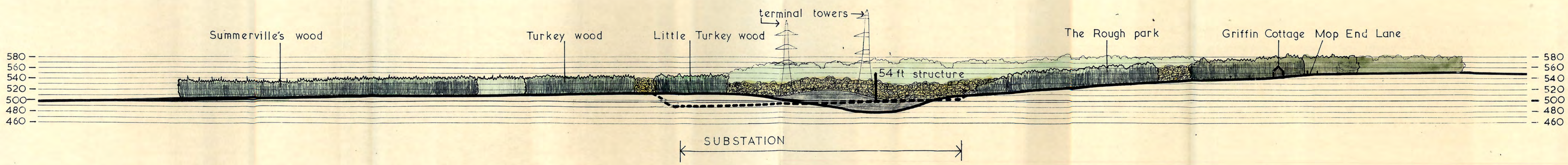
<u>Chapter Eleven</u>

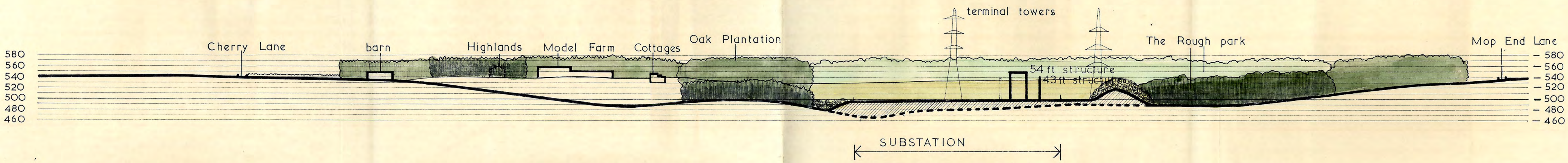
None

MAP 13

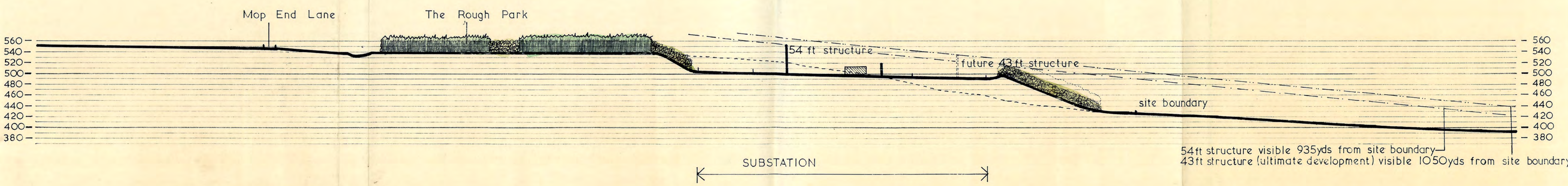

KEY
SUPERGRID LINES WITH ONE OR MORE OF THE CIRCUITS WORKING AT 400 KV
SUPERGRID LINES WORKING AT 275 KV OR LOWER VOLTAGE
NEW SUPERGRID LINES DISPLACING EXISTING 132 KV GRID LINES WHERE POSSIBLE
LINES WHERE SOME UNDERGROUNDING IS ENVISAGED
SUPERGRID SUBSTATIONS
OTHER SUBSTATIONS
COUNTY BOUNDARIES
SOUTH OF SCOTLAND ELECTRICITY BOARD
Blyth
Stella
Boldon
Harker
Hartmoor
Norton
Lackenby
Skelton Grange
Monk Fryston
Elland
Ferrybridge
Penwortham
Rochdale
Thorpe Marsh
Keadby
Kirkby
Stalybridge
West Melton
Carrington
West Burton
Connah's Quay
High Marnham
Ffestiniog
Trawsfynydd
Staythorpe
Oswestry
Willington
Castle Donington
Drakelow
Ironbridge
Penn
Hams Hall
Feckenham
Sizewell
Hereford
Sundon
Bradwell
Oldbury
Elstree
Pyle
Whitson
Uskmouth
Iver
Barking
West Thurrock
Tilbury
Aberthaw
Melksham
Northfleet
West Weybridge
Chessington
Canterbury
Fleet
Hinkley Point
Taunton
Lydd
Dungeness
Cross Channel Cable
200kV Direct Current
Exeter
CENTRAL ELECTRICITY GENERATING BOARD
HEADQUARTERS
400/275 KV SUPERGRID-1970
EXISTING & AUTHORISED TRANSMISSION FACILITIES AS AT 31. 3. 61. IN GREEN
ADDITIONAL TRANSMISSION FACILITIES ENVISAGED BY 1970 IN RED
FURTHER POSSIBLE TRANSMISSION REQUIREMENTS BY 1970 IN BLUE
SCALE OF MILES
10
0
10
20
30
40
50
60
GENERAL
41/4799B



Sectional Elevation A - A



Sectional Elevation B - B



Section C - C

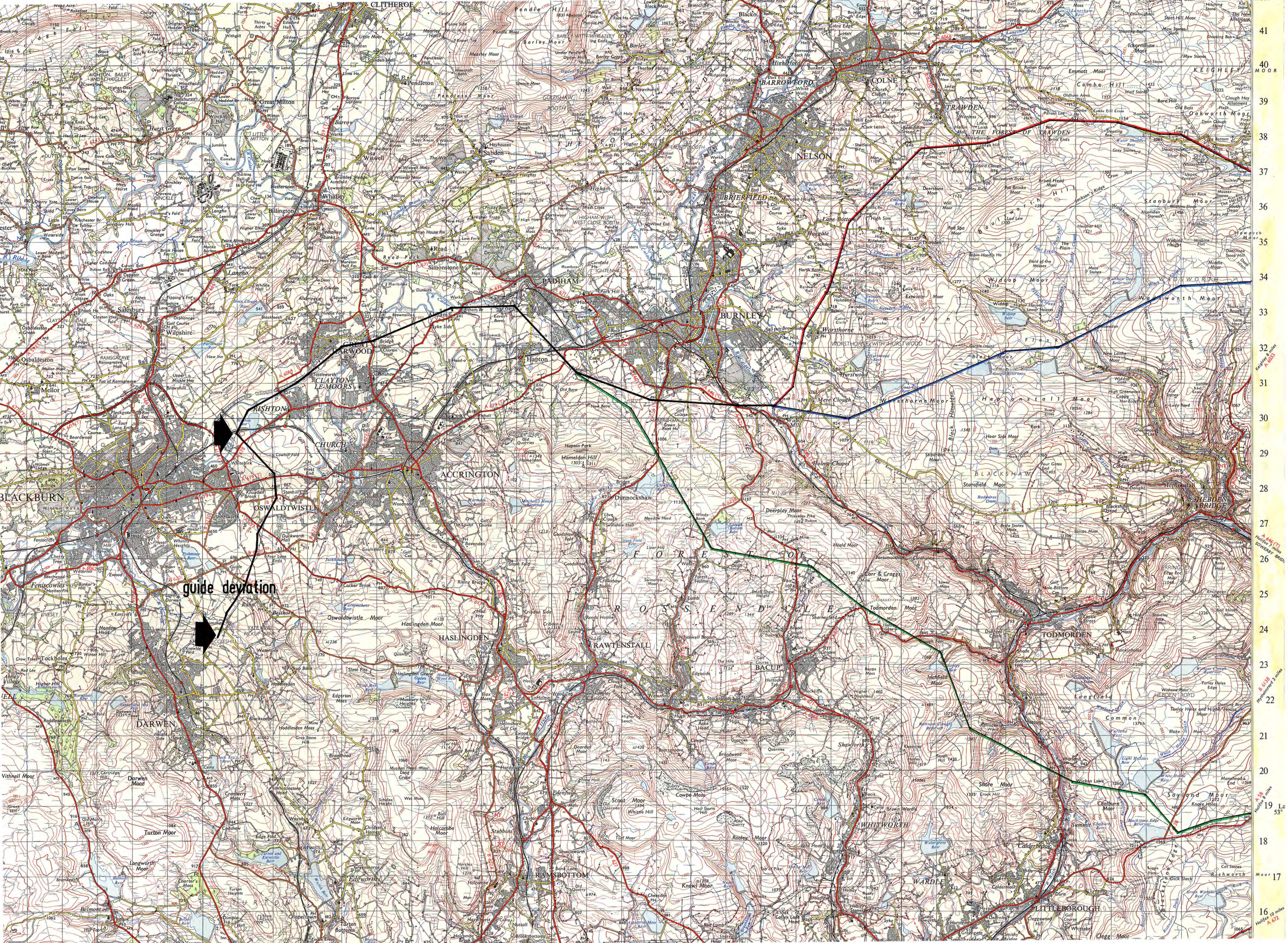
SOUTH BUCKS 400/132 kV Substation

LANDSCAPE SECTIONS

Horizontal scale 1/2500 **Vertical scale 1/1250**

GG 3 A


SOUTH BUCKS 400/132 kV Substation
PROPOSED LANDSCAPING
Scale 1:2500
N
400 kV line to Cowley
FP 13 to Little Missenden
FP 28 to A 413
New position of ZL 448
ZL 448 Crossing tower
PMA 173
PMA 174
PMA 175
PMA 176
PMA 177
PMA 178
PMA 179
Off site planting by agreement if requested.
Mop End Farm
Rose Cottage
Griffin Cottage
to Beamondend Farm FP 10
FP 11
to Beamond End
Shardloes Cottage
Mop End Lane
LITTLE TURKEY WOOD
TURKEY WOOD
LITTLE SUMMERVILLES WOOD
SUMMERVILLES WOOD
FP 27
to Shardloes
WHEATLEY WOOD
400kV Substation
132 kV Substation
ROUGH PARK
OAK PLANTATION
Beechlea
To High Wycombe
Lodge
PENN WOOD
Model Farm
Highlands
Woodrow High House
Gate House
400kV line to London
To Amersham
To Penn Street
A. 404
Cherry Lane
ZL 449
ZL 450
ZL 451
ZL 452
400 kV line to Iver
A
B
C
New tree and shrub planting.
Existing forestry planting.
Existing mixed planting.
Limit of proposed acquisition.
Existing contours altered.
Diverted footpath.
Existing hedgerows.
GG 2A


CLITHEROE
BARROWFORD
COLNE
TRAWDEN
NELSON
BRIERFIELD
PADIHAM
BURNLEY
HARWOOD
RISHTON
CLAYTON LE-MOORS
CHURCH
ACCRINGTON
BLACKBURN
OSWALDTWISTLE
guide deviation
HASLINGDEN
RAWTENSTALL
BACUP
TODMORDEN
DARWEN
RAMSBOTTOM
WHITWORTH
WARDLE
LITTLEBOROUGH


MAP 34
KEIGHLEY
BINGLEY
BAILDON
YEADON
SHIPLEY
DENHOLME
BRADFORD
QUEENSBURY
SHELF
HALIFAX
SOWERBY BRIDGE
BRIGHOUSE
CLECKHEATON
LIVERSEDGE
ELLAND
RIPPONDEN
MIRFIELD
HUDDERSFIELD
ripponden deviation

SOUTH BUCKS 400/132 kV Substation
LANDSCAPE APPRAISAL
Scale 6" to 1mile
GG1A
limit of area shown on model
photographic viewpoint
East Claydon - Iver 400 kV
Cowley - Iver 132 kV
Cowley - Iver 132 kV
East Claydon Iver 400 kV
1 mile
1 mile
1·5 miles
2·0 miles
2·5 miles
3·0 miles
N
AMERSHAM
UPPER PARK
COLESHILL
Little Missenden
400
500