POINT TO POINT

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Points of View

IN THE 15 YEARS since the end of World War II, there has been a substantial increase in the number of telephones in use throughout the world. Facilities in most territories have participated in this increase, which has been supported by corresponding improvements in international and inter-continental links. Nevertheless the major development has been in North America and, to a somewhat lesser extent, in Europe. Facilities in many of the other parts of the world are still, by comparison, somewhat restricted, but the increase in tempo of world communication requirements may well produce, in the next decade, a rapid expansion. If experience on the transatlantic cable is any guide, the Commonwealth Co-Axial Telephone Cable, which should be completed within this period, will stimulate a very great increase in telephone traffic, in turn promoting the expansion of national trunk telephone networks.

It follows, therefore, that much of the development in trunk telephone networks has taken place in areas where skilled planning, operational and maintenance facilities are most highly developed. The problems involved are well understood in these territories but elsewhere, where facilities may be more limited and the problems of staffing more severe, planning and operation present greater problems, in part due to a lack of statistics on which increased system capacity can be provided with confidence.

It was therefore felt that while a review of the factors involved in planning and executing a major trunk communication expansion would be of wide interest, it would be more valuable when considered in conjunction with the problems that still remain once an expanded system has been installed, namely maintaining the system in efficient order and providing, if not already available, adequate numbers of trained staff from local resources. Information on these aspects of network operation is much harder to come by and it was therefore felt that any discussion on the problems could, with advantage, be coupled with actual experience in particular cases.

For this reason an issue of *Point to Point Telecommunications* has been prepared reviewing the problems involved in providing improved facilities, in maintaining performance once installed, and in providing local staff for carrying out this work, illustrated by the experience of what is now the Federation of Nigeria over the period 1949-1960. We are happy to acknowledge the co-operation received from the Posts and Telegraphs Department in the preparation of these articles, and the permission for us to publish actual results from the operation of their trunk network.

As a result, much of this discussion has revolved around the establishment of trunk facilities of relatively limited channel capacity, utilizing in the main radio equipment which operates in the VHF frequency bands. It will be readily understood that the basic considerations are, however, far wider, and can be applied to the planning of large systems involving microwave equipment handling hundreds of telephone channels or television. A.J.W.

National Telecommunication Network Planning

E. G. HANCOCK

This article reviews the problems which must be considered when a major expansion of telecommunications facilities in a territory has to be undertaken. While wide variations will occur, dependent on the particular circumstances, it is possible to discuss a general pattern. This pattern, illustrated by a particular development in Nigeria, touches on many of the factors which must be taken into account.

1 INTRODUCTION

WORLD WAR II left an interesting communications problem in many parts of the world. A general shortage of national telephone and telegraph circuits, coupled with the poor condition of what was actually in service, led to a widespread desire to re-equip and expand many communications systems. Nowhere was the problem more acute than on the continent of Africa. Here the old colonies were at the dawn of an era of rapid economic and political change, and existing communications facilities were obviously inadequate to either encourage or support these changes.

This article summarizes the general problems that confront administrations under these circumstances and will, by way of illustration, refer to the particular solution adopted by the Posts and Telegraphs Department of Nigeria during the years 1950-1958.

2 ADMINISTRATIVE PLANNING

If an administration is planning a major increase in internal long distance communications, the first step is to decide upon a logical routing for an expanded system and the preferred points of access to it. In outline this is not too difficult. Existing and planned centres of population and industry, together with road, rail or river transport routes, will be known. The problem resolves itself into linking the most important of the former by routes that will closely follow the latter.

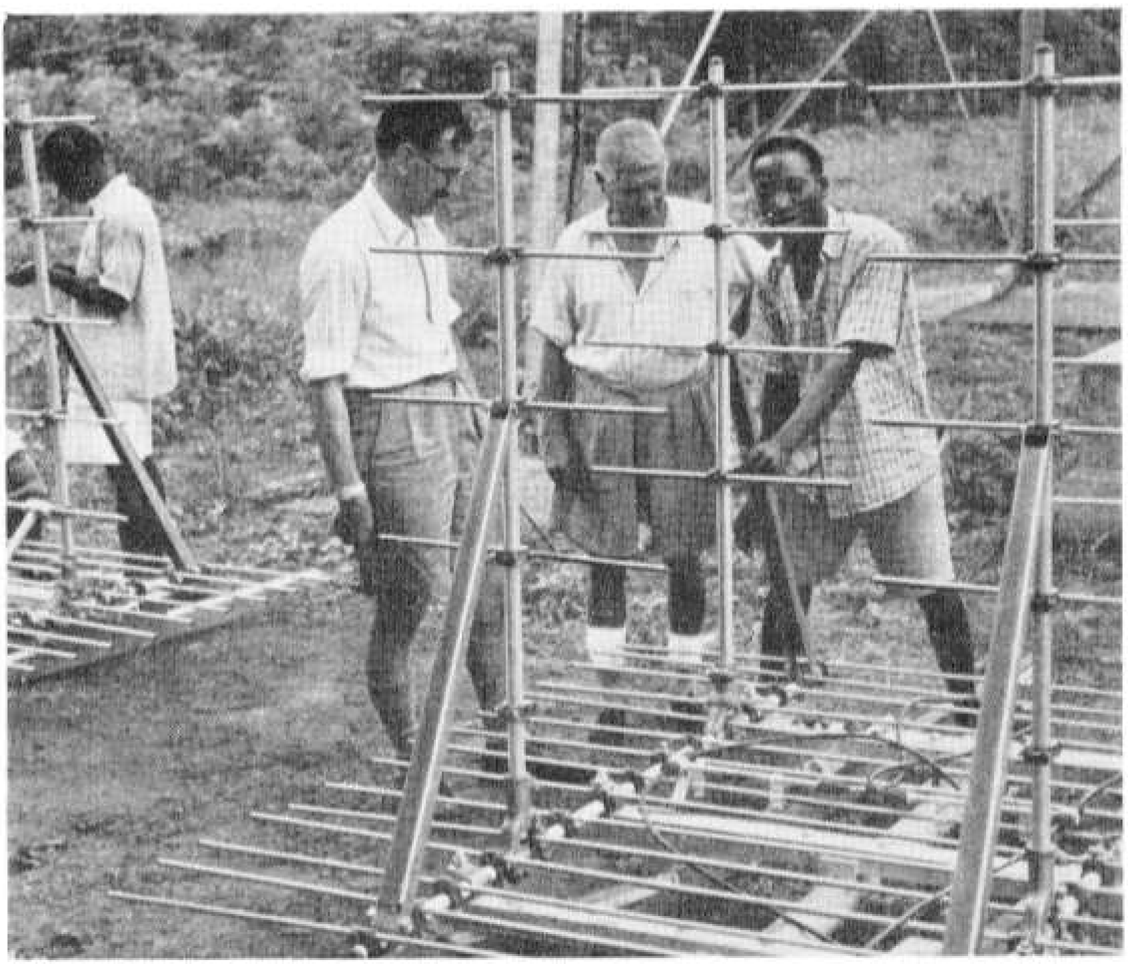
The second step is to make an estimate of the required capacities of the various sections of the system. If this major expansion is the first of its kind in the country, it is unlikely that sufficient statistical evidence will be available from local sources to make this estimate accurate, and as provision will have to be made for probable expansion, the problem is not simple. Statistics from other countries can be used, but must be treated with caution, as required facilities and subsequent expansion will be closely related to the economy and population distribution of the country concerned. Rough estimates can, however, be made. Assuming negligible existing facilities, the initial capacities of the sections of the planned system can be built up by considering the proposed circuits to consist of three types, as shown in Table I.

Table I

Circuit Category	*Initial Circuit Capacity*
CATEGORY 1 Primary centre to primary centre	3 per 200 subscribers at the smaller centre
CATEGORY 2 Secondary centre to associated primary centre	2 per 150 subscribers at the secondary centre
CATEGORY 3 Secondary centres to other secondary centres	1 per 150 subscribers at the smaller centre

These figures are conservative, and modifications will normally increase the allocation. As an example, the case of two large centres of population less than fifty miles apart can be considered. Although the system linking these two centres will be an integral part of the trunk network, it will tend to become a single 'urban' network, in which case the allocation should be trebled. Secondary centres that are closely tied to their associated primary centre by any common industry or economic programme will need more circuits than those that are not

Survey teams on the road



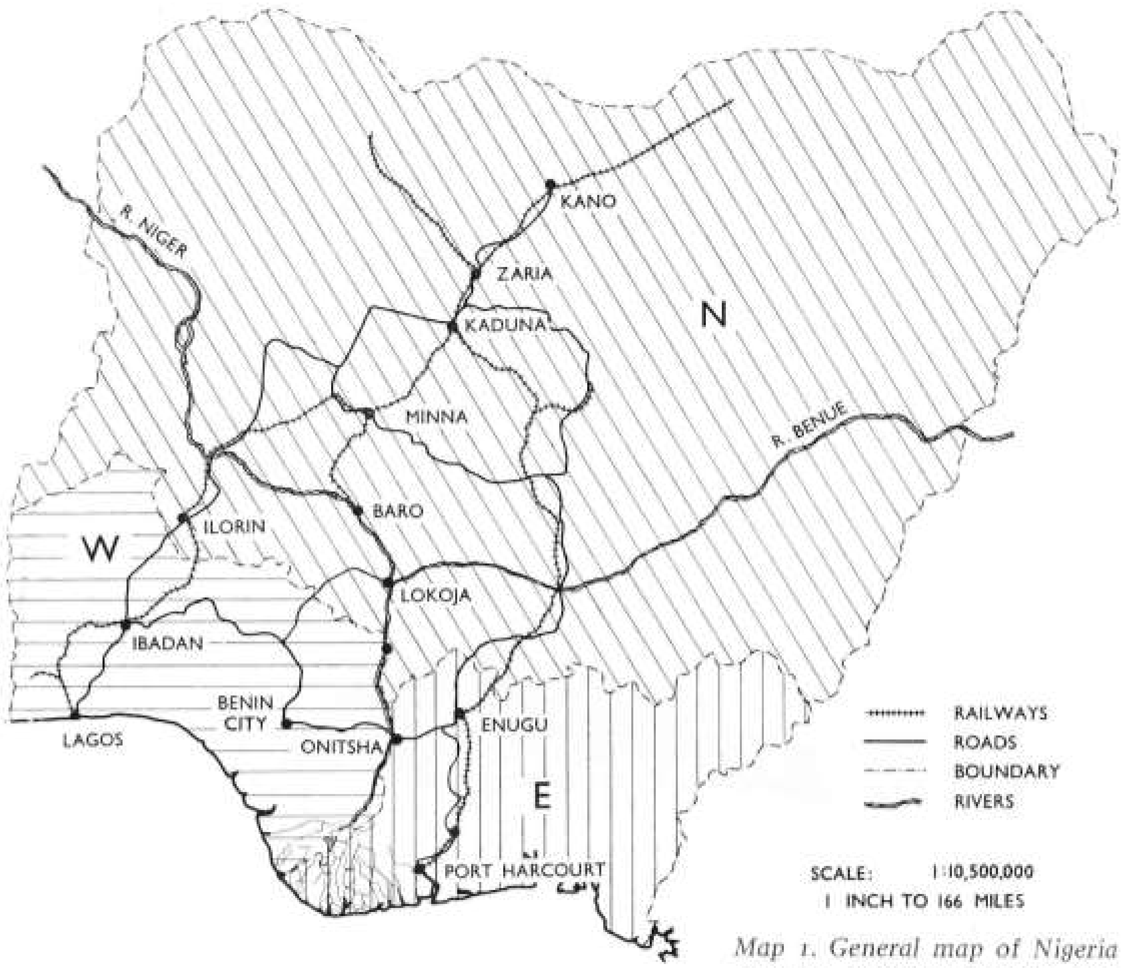
Adjusting VHF aerials prior to installation and, contrary to popular belief, a small political centre will write more and talk less than a local business centre of equal size. The variations are infinite and can only be considered in detail by the administration concerned.

Again assuming negligible existing facilities, an accurate estimate of probable expansion is even more difficult. Two particular systems, one linking Lagos and Ibadan in Nigeria and the other Singapore and Kuala Lumpur in Malaya, will serve to illustrate how rapid the growth can be. In 1946 both systems were of 4-channel capacity, by the late 1950s both were using VHF systems of 96 and 144 channel capacity respectively. By the early 1960s both will be using heavily loaded 240 and 600 channel UHF systems respectively. It is not suggested that all sections of all systems will grow at this rate but it is suggested that administrations must be generous in their allowance for future expansion. The minimum expansion factors that should be considered are set out in Table II. For larger capacity sections of any scheme it could be expected that these expansion figures would cater for a period of five years following the commissioning of a new system.

Table II

Circuit Category	*Provision for Expansion*
CATEGORY 1 Primary centre to primary centre	x5
CATEGORY 2 Secondary centre to associated primary centre	x4
CATEGORY 3 Secondary centres to other secondary centres	x3

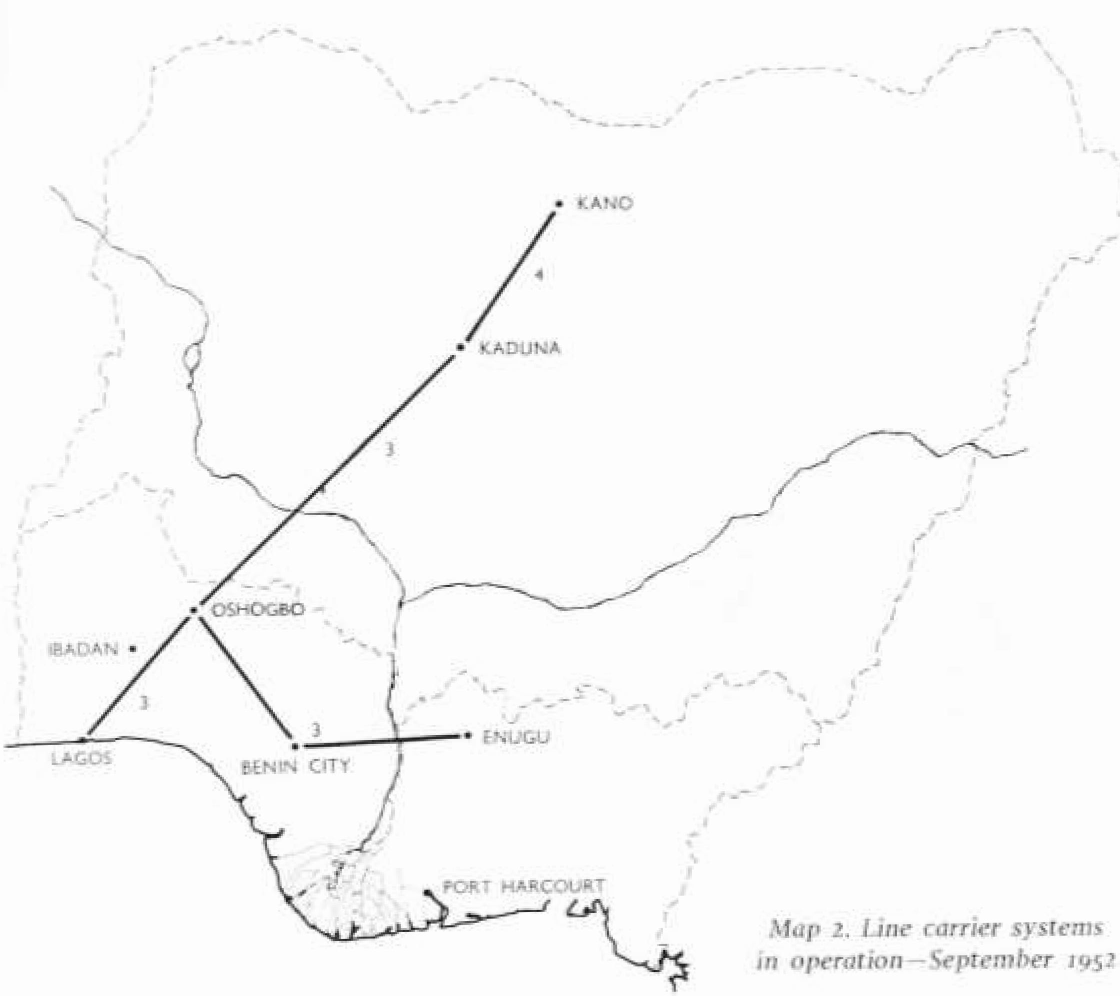
Network routing and traffic capacity having been decided, the type of system must be considered. Dependent upon system capacity, five



Map 1. General map of Nigeria showing political division and road and rail routes

alternatives exist; open wire line or coaxial cable, VHF or microwave radio relay, or tropospheric scatter. Many highly controversial arguments have been advanced in favour of the line and radio alternatives, and it is not possible in brief compass to review them. Suffice it to say that the costs of installation are comparable when terrain is favourable, with advantage in favour of radio as channel capacity increases and terrain becomes more difficult. Costs of maintenance, on the other hand, favours line systems particularly if power has to be provided by prime movers at radio repeater stations. As system size increases, the difference tends to be reduced.

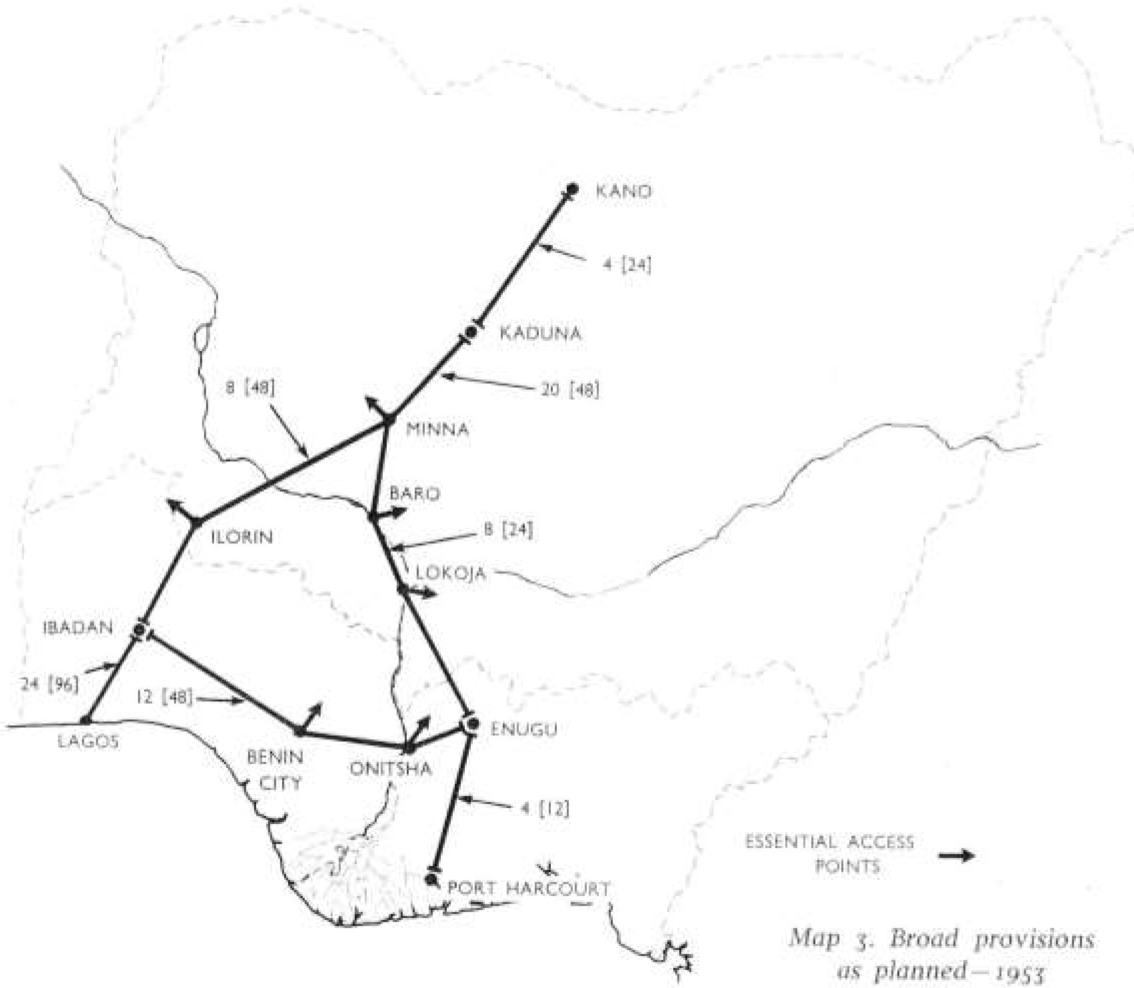
Two other factors are worthy of note. The first is security. A radio



Map 2. Line carrier systems in operation—September 1952

system is easier to protect than its line equivalent. The second is flexibility. Expanding line routes is a major and costly operation, redeploying them is impracticable. Radio, on the other hand, can be installed below its maximum capacity and subsequent expansion is then simple and without expense except for additional carrier equipment. If eventually overloaded, it can be replaced and redeployed quite simply. In a rapidly expanding system, therefore, the flexibility of radio is an important advantage.

Nigeria provides an example to illustrate these problems and their convenient solution. Map 1 shows how the country is divided. The densely populated Western Region has its capital at Ibadan, a city



Map 3. Broad provisions as planned—1953

with a population of 500 000, with the Federal Capital of Lagos as the major port and most important trading centre in the country. The Eastern Region has its capital in the coalmining city of Enugu, linked by road and rail to Port Harcourt. The large Northern Region has its capital in Kaduna, some 150 miles south of the important agricultural and trading centre of Kano, also the location of the international airport.

In 1949, the trunk telephone facilities available for the whole country were very limited and the initial administrative decision to expand them greatly was then taken. As an interim measure the existing line routes were developed until, in 1952, immediately prior to the start of the new system, they were as shown on Map 2.

The P & T Department had decided to link the three regional capitals in the form of a triangular backbone from the apices of which spur systems would run to Lagos, Port Harcourt and Kano. The routing of the system was to be such that it followed, as closely as possible, existing road, rail or river transport routes. The new system would link the primary population and political centres, while the centre triangle would provide security against any possible operational failure of one of the sides. By following transport routes it would also provide convenient access at intermediate towns. Map 3 shows the broad provision of facilities as foreseen at this stage, the figures in brackets indicating the maximum system capacity at various points.

Existing line routes could not be repaired or upgraded to meet the foreseen requirements. New, accurately balanced and transposed line routes would have to be built, or an entirely new system employed. At this time the alternatives in new systems were limited. Tropospheric scatter was in its infancy, coaxial cable systems were not feasible because of cost, which left VHF or UHF Radio Relay systems using frequency division multiplex channelling equipment as the only practical alternative. Of these two, UHF systems could be ruled out initially as the higher cost was not justified by the number of channels involved. The overall problem thus resolved itself into a consideration of the relative merits of line or VHF radio relay systems.

Reviewing all the factors involved, the P & T Department decided in favour of the VHF radio relay system for the major portion of the planned system.

The overall correctness of this decision has been demonstrated in later years by the considerable post-installation expansion that has taken place—an expansion only made possible by the economic success of what became known as the Nigerian VHF Main Trunk Scheme.

3 DETAILED PLANNING AND ROUTE SURVEY

Once a decision to use radio has been taken, it becomes necessary to examine all problems in more detail. For this to be done with any degree of precision a radio survey will have to be conducted over the appropriate sections, defining suitable sites precisely.

This field survey work is of great importance. Unless the maps of the routes involved are extremely accurate and unless there is sufficient statistical information concerning the propagation conditions likely to be encountered, it is extremely dangerous to install a large radio scheme without first checking the radio performance of each path. It is not to be considered that this work will merely consist of erecting masts on casually selected sites and checking that propagation conditions between these sites are sufficiently favourable. Consider the obvious criteria for an economic system :

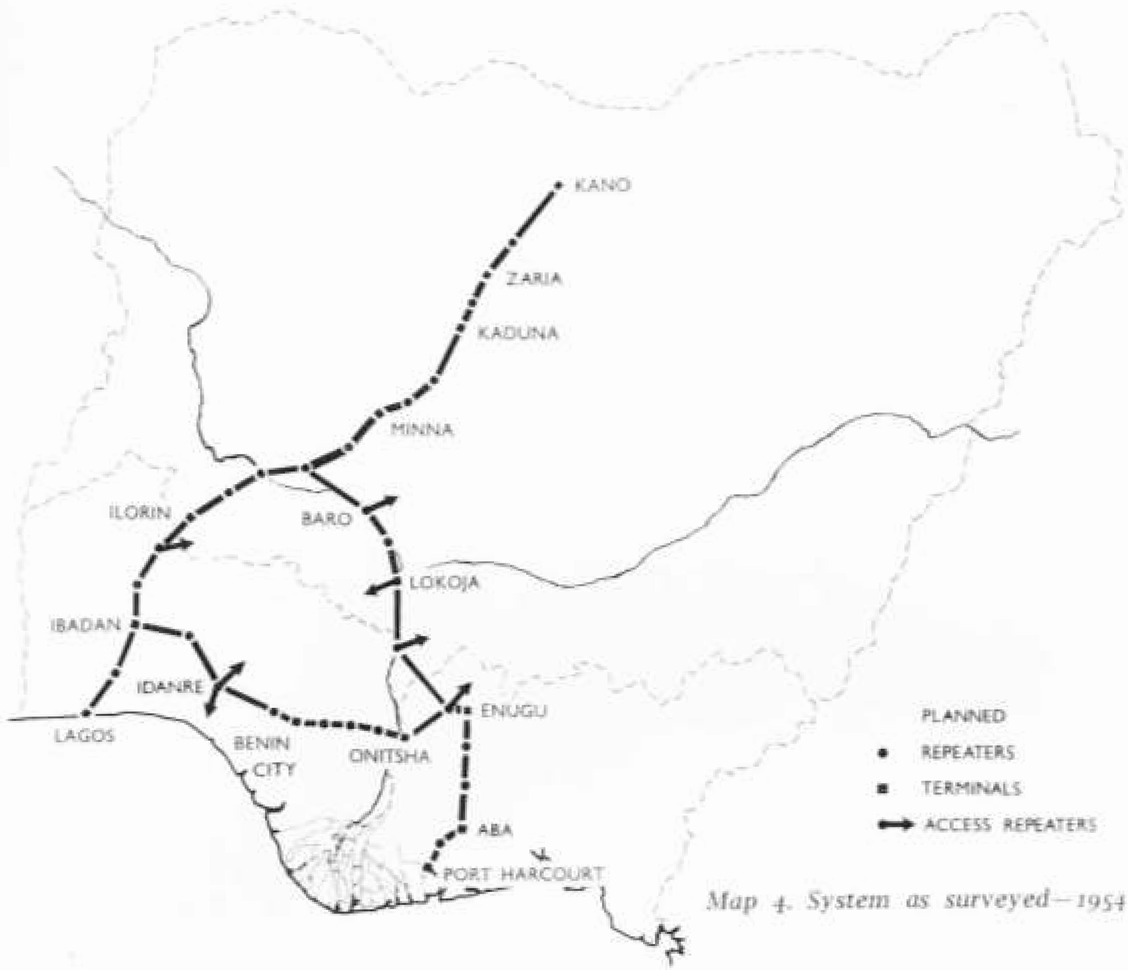
(1) The maximum possible distance between stations (i.e, the minimum number of stations and thus the minimum capital cost).

(2) The maximum accessibility of stations (i.e, the minimum maintenance difficulties and access road costs).

(3) The minimum distance between stations to which traffic access is required and their associated local exchanges (i.e, the minimum cable tail cost and minimum level loss on simple terminated circuits).

It is immediately clear that criterion (1) is generally diametrically opposed to (2) and (3). The survey engineer has to find, therefore, a series of sites which can be likened to operating points set in a field of opposing forces. Close co-operation with the administration is involved, as only they will be able to adjust planned arrangements to suit the locations indicated by the propagation tests. These points will be illustrated.

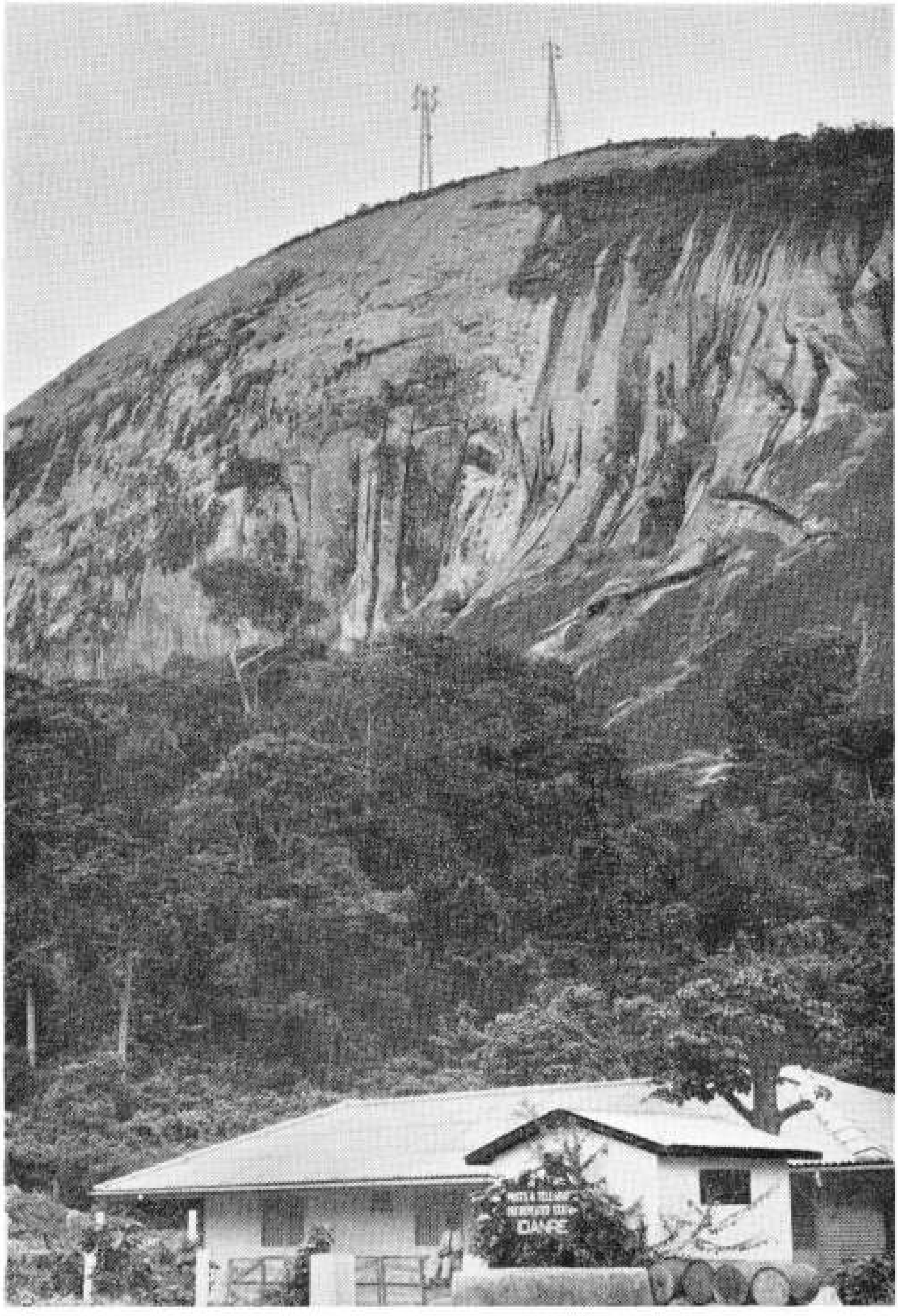
In Nigeria, the P & T Department chose Marconi Type HM 100 VHF multichannel radio equipment, and asked the Company to conduct a survey over the proposed routes. It was calculated that this would involve tests over about fifty paths and would take about two years to complete. The P & T Department also decided that the survey should start on the route Lagos—Ibadan—Benin—Enugu, thus permitting the most important section, Lagos—Ibadan, to be installed while survey work was proceeding on the remoter sections of the scheme. A special survey section was established comprising three mobile teams each led by one of the Company's engineers and equipped to form a completely independent mobile station. The movement across country was made in



Map 4. System as surveyed—1954

the form of a massive game of leapfrog, the end unit always hopping over the other two to start on a new path. This programme started in Ibadan in 1952 and continued in regular progression until Enugu was reached, some nine months later. Here a brief halt was called for a refit of men and material. As results were obtained they were sent to the Marconi propagation laboratories at Great Baddow, where they were rigorously checked. When considered necessary, sites and paths were re-checked and changed until the requirements for the system were fully satisfied. The final system is shown on Map 4.

These results involved a site that illustrates nicely the solution of the problems involved. This was Idanre, between Ibadan and Benin. The site was the top of a 750 ft outcrop of rock, some 20 miles off the main



Idanre repeater site. The diesel generators are located at the foot of this 750 ft crag for ease of access; the radio equipment is installed adjacent to the aerials, access to which has to be on foot road, along what was then a secondary bush road. The rock was so steep that it would only be possible to reach the summit on foot, and thus suffered a very poor accessibility factor indeed. However, it would save one, and possibly two, additional repeater stations, and consultation with the P & T Department revealed that it could also be used as an unattended switching station with traffic access for secondary circuits to two towns in the area. This made it an economic proposition and the site was chosen.

The survey teams were now ready to move off on to the section Enugu—Kaduna, which would link up the river ports of Lokoja and Baro. It was to serve what was primarily a river transport route and it was expected that road access to stations would be more difficult than hitherto. The survey work proceeded and as it did so the outline sketch of the system crystallized into a chain of planned repeater stations.

By April 1953 the central triangle was completely surveyed and all that remained were the two spurs Enugu—Port Harcourt and Kaduna—Kano. Installation work started on the link Lagos—Ibadan and was well under way by the time the survey finished in Kano. The work was now entering a new phase.

4 INSTALLATION AND COMMISSIONING

During the progress of a survey an installation programme will be established. Of obvious importance is the choice of the first section to be installed. There are two lines of thought:

The first:

To install one of the less important and cheaper sections first, in order to test the scheme in general. This ensures that the scheme is finally committed to equipments of locally proven efficiency.

The alternative:

To install the most important section first. As this section will usually link the two most important centres, it should prove an immediate economic success. This will ease the flow of capital for further sections and may considerably augment it due to increased income.

For a wealthy administration the first, offering as it does certain technical security, might be advantageous. However, the possibility of serious technical error is becoming increasingly remote, and an administration that is stretching its resources in order to affect a major expansion could well adopt the second as, in this case, an immediate success might make a considerable difference to the speed with which the complete scheme is installed.

The choice having been made, it should then be possible to produce an overall programme for the complete installation. This plan should take into account increased or new local exchange facilities at points of access, and a manufacture and supply programme will have to be drawn up by the contractor to suit this programme. It then remains to consider the many problems attendant upon the actual physical installation itself. These can be divided into four broad sections:

(1) The building of access roads, station buildings, footings for large towers and any other civil engineering activity.
(2) The erection of towers, masts, aerials and feeder cables.
(3) The installation of diesel generators and control equipment, power cables, switches and transformers.
(4) The installation and commissioning of radio and carrier equipments. (On large schemes it may be necessary to provide for a separate carrier section.)

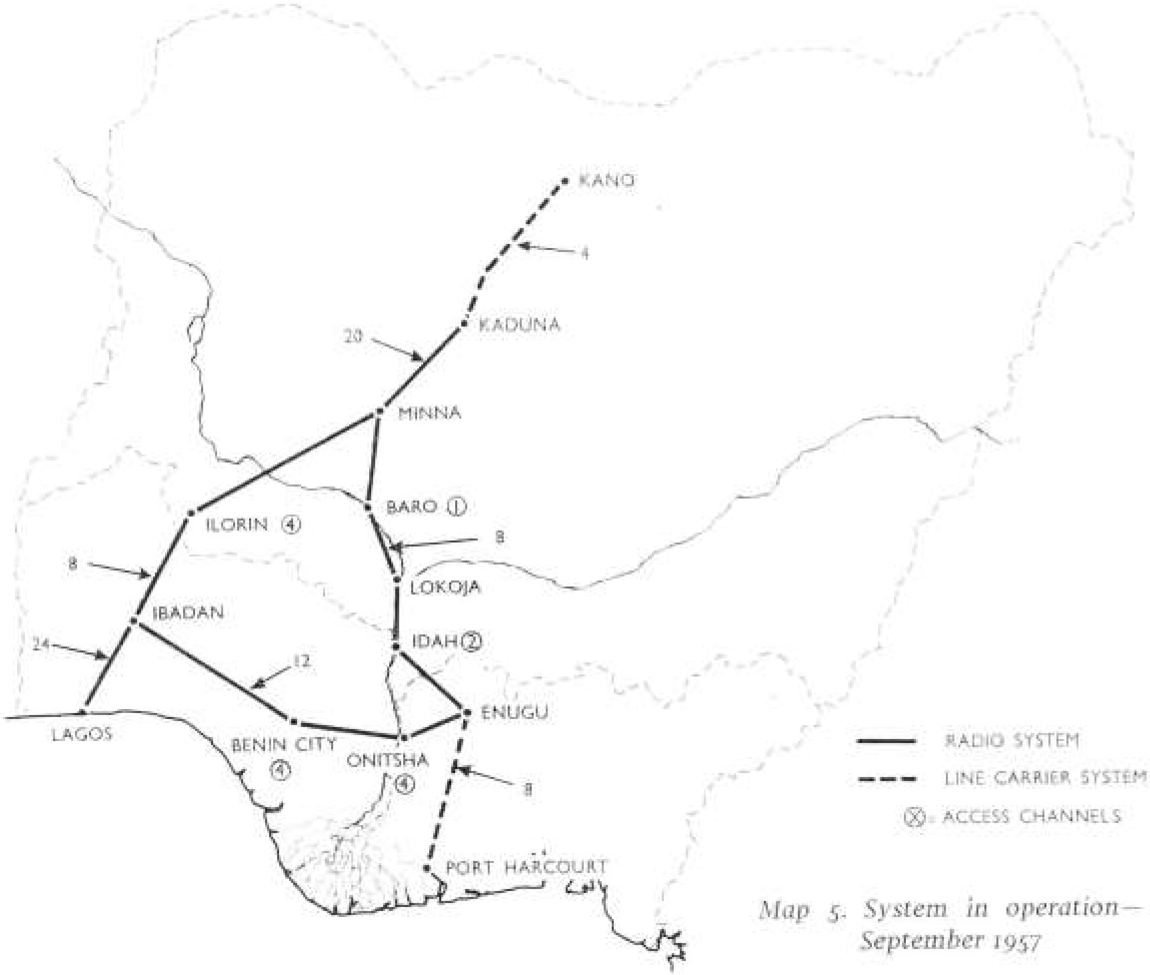
As shown earlier in this article, control of a survey team is a relatively simple matter. Two or three units move across a country at approximately the same speed, as each is doing the same type of work. In the case of installation, there are at least four different units, all doing different work at different speeds at different stations. Ideally, each unit should receive materials at exactly the right time, start work and proceed at a predetermined speed. Each should complete its work such that another unit can move in and continue the process of building a complete station. Unfortunately, too detailed an installation plan frequently proves unworkable, and much will depend on the ability of the Supervising Engineer to minimize the inevitable dislocations, within an overall installation programme.

Once the installation programme has been determined, some consideration can be given to the personnel required for the installation team. Again, a general case must be considered, and the numbers suggested being subject to modification to suit any particular case. For simplification it will be assumed that station buildings are ready and that adequate transport is available. The minimum personnel required for each installation section will be as shown in Table III.

Table III

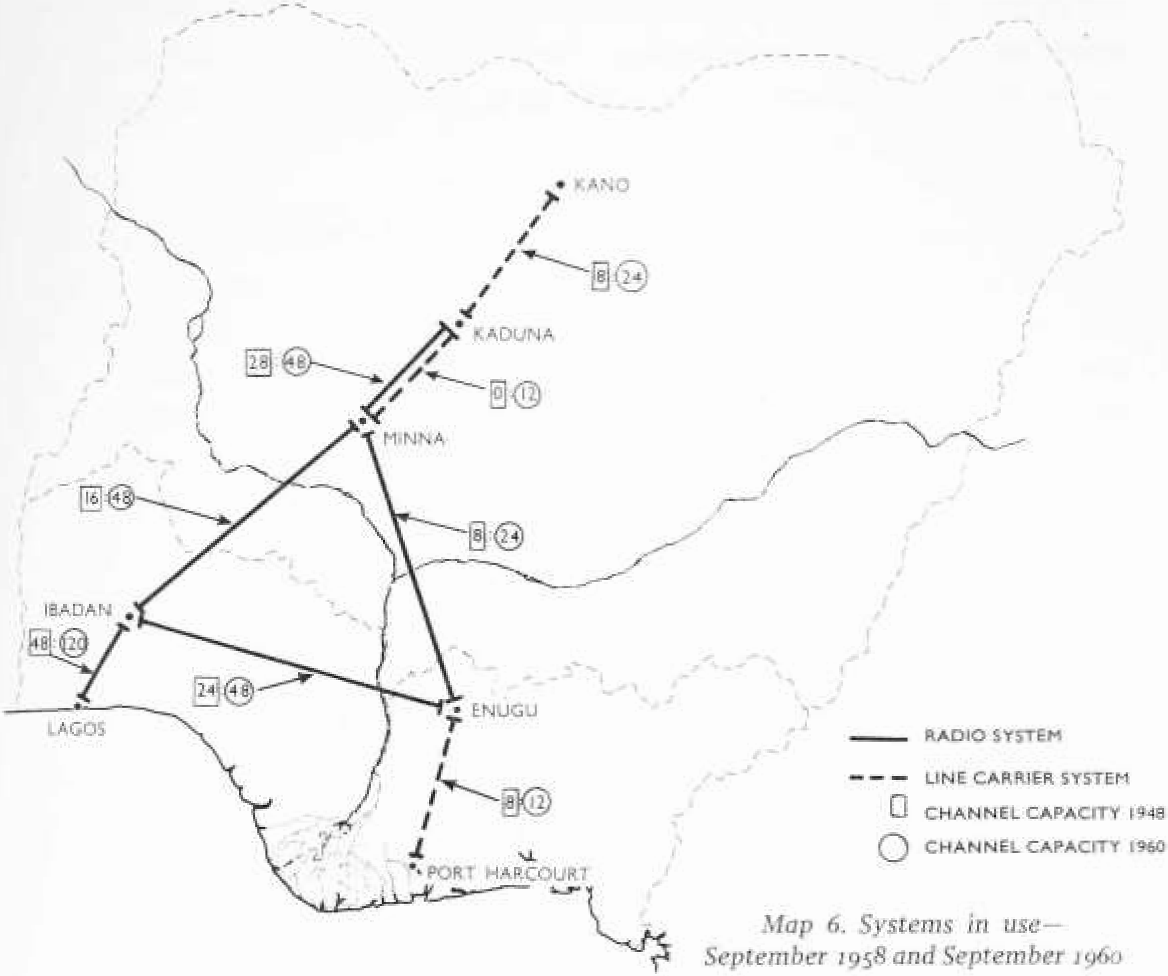
RIGGING SECTION	For towers not exceeding 200 ft in height, 1 experienced rigger plus 5 assistants. For towers exceeding 200 ft, 2 experienced riggers plus 15-20 assistants.
POWER SECTION	1 engineer plus 1 experienced mechanic plus 5 assistants.
RADIO SECTION	1 engineer plus 3 assistants.
ADDITIONAL	1 engineer in charge, who will have to offer technical assistance to any section that needs it, in addition to other administrative duties. 1 superintendent of stores and transport, who will facilitate customs clearance and supervise transport in the country.

Reverting to the Nigerian example, the most important section, Lagos—Ibadan, was installed, with only limited technical assistance from the Company, during the later stages of the survey and went into traffic in 1953. The economics of the system were studied for a period and proved to be such that the decision to proceed with the major expansion was taken in 1954. Progress was to be along the route Ibadan—Enugu but as technical and administrative personnel were in such short supply at this time, the Company was asked to assume field responsibility for part of the Civil Engineering Section, the Rigging Section, the Power Engineering Section (with the exception of cables and transformers) and the Radio and Carrier Section. The stores and transport facilities of the Department were made available for installation purposes, and where these were insufficient, additions were made by the Company and subsequently taken over by the Department. In July 1955



Map 5. System in operation—September 1957

the first shipment of equipment arrived in Lagos, and the power and rigging sections started work. They were followed, three months later, by the radio section and work was proceeding smoothly in the direction of Enugu when it became known that Her Majesty the Queen planned to visit Nigeria in February 1956. Many plans were accelerated and amongst them was the VHF installation to Enugu. It was agreed that the final installation of the section could not be completed in time but a provisional installation was considered possible. Considerable efforts to this end were successful, and the circuits provided good news coverage and broadcast facilities during Her Majesty's visit. This concluded, it was noted with pleasure by the Department that, far from diminishing,



Map 6. Systems in use—September 1958 and September 1960

the traffic over the system continued to grow. In this case the installation was completed, tested and commissioned without going out of traffic for more than short and unavoidable periods. This inevitably delayed completion of the work but the Department was happy that this should be so.

Small teams were left to complete the Ibadan—Enugu section while other teams started on the installation of the sections Ibadan—Minna and Enugu—Minna. Work continued fairly rapidly on these sections and Minna was reached in December 1956. It was decided to complete the section Minna—Kaduna as quickly as possible, despite the lack of some small items of equipment. When this was done the teams were cut in size and then moved back over the system, installing outstanding items, testing and commissioning. The last link to be officially accepted by the Department was Lokaja—Minna in November 1957. The system, shown on Map 5, was complete.

5 CONCLUSIONS

The problems involved in radical expansion of communications facilities are many and complex. The cost is usually high, and the returns are, even when considerable statistical evidence exists, not able to be stated with certainty. Often, extension beyond the range of local experience is involved, and for these reasons there is considerable temptation to err on the side of caution. Experience in many different circumstances suggests that the estimate of demand for improved services is almost always pessimistic and, in view of the high cost of obsolescence or redeployment, it is prudent to provide an extremely adequate margin for expansion. Further confirmation of this trend is given in Map 6, which shows the increase of capacity which has proved necessary over a period of only two years—1958 to 1960. Such expansion can usually be more economically provided for a radio system than for a line as, with proper planning at the outset, a large proportion of the capital investment can be utilized unchanged for a much enlarged system.

Acknowledgment

The author wishes to thank the Director, Nigerian Posts and Telegraph Department, for permission to publish this article.

E. G. HANCOCK was born in 1930 in India. He was educated at the Royal Merchant Navy School and at the Mid-Essex Technical College. He joined the Marconi Company as an apprentice in 1946 and was transferred to the engineering staff in 1951. For two and a half years he worked on telecommunications development projects. He has been a member of many survey teams and has done survey work in Greece, Jamaica, Ghana, Nigeria and Angola.

Performance and Maintenance of the Nigeria VHF Trunk Network

L. A. SUMMERLAND, A.M.I.E.E

Published information on the performance of multichannel radio networks is very limited, not least because of the time which must elapse before reliable conclusions can be drawn. This article sets out the performance obtained on the Nigerian system over a two-year period, and describes the maintenance organization which has been provided.

1 INTRODUCTION

THE LAST TEN YEARS have been marked by a rapid increase in the number of multichannel radio systems, operating in the VHF and microwave bands, used for relaying trunk telephone and telegraph traffic. These systems utilize equipment specifically designed for this purpose which has proved to be highly reliable, but of necessity it has to be rather complex in order to meet operational requirements and the exacting performance specifications that are laid down. Occasional faults are inevitable so that adequate facilities must be provided for their speedy repair.

Very little has been published on the performance in service of systems of this kind, and it is felt that the results obtained on a typical system may, therefore, be of interest. The performance obtained is obviously dependent on the maintenance facilities that are available, and this article describes the organization which was set up to maintain the VHF radio trunk network in Nigeria immediately the system was commissioned. The system comprises a main radio network of 1 000

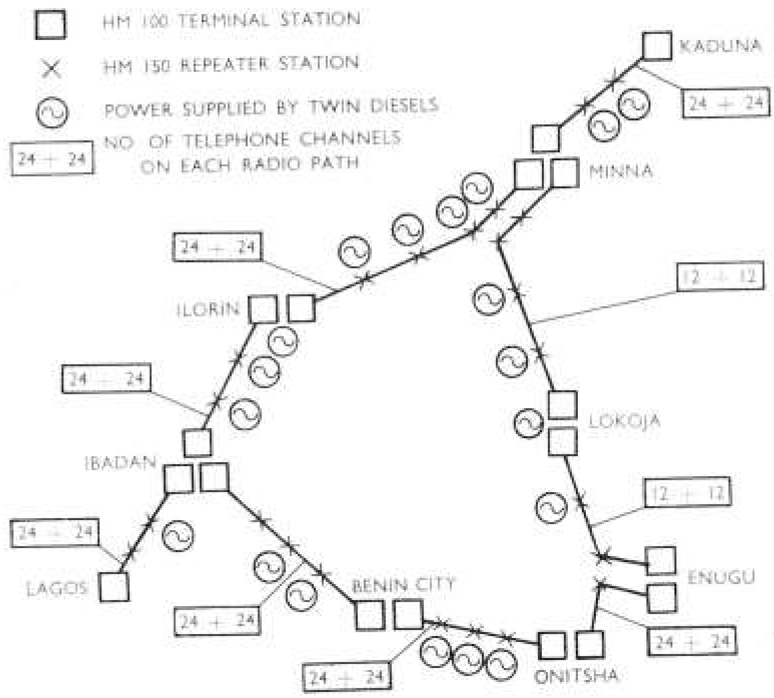


Fig.1. VHF multichannel system—April 1960

route miles forming 43 000 channel miles. It employs Marconi equipment Type HM 100 and the system layout is illustrated schematically in Fig.1.

Where a high degree of reliability is necessary the most satisfactory solution to the problem of occasional faults on a multichannel system is to provide standby equipment which can be switched into service automatically on failure of the operational equipment. In Nigeria, however, it was decided to install a twin-path system, both paths of which would carry traffic, and therefore any failure in the system will result in outage time and loss of traffic. This situation has been met by dividing traffic into priority (which includes major VFT systems) and non-priority groups, and by arranging for the priority groups to be patched to the non-priority path in the event of a failure of the main path. This results in loss of non-priority traffic.

It should, therefore, be kept in mind that data on system performance quoted in this article mainly relates to the non-priority paths. Priority traffic is only lost when both paths fail simultaneously, a much smaller percentage of the time. The absence of a standby path increases the need for efficient maintenance and fault control, procedures for which are also described.

Responsibility for maintaining the network has been entrusted to a Marconi engineering group seconded to and forming part of the Post and Telegraphs Department. This group is entitled the 'Nigerian Maintenance Service'; 26 radio and transmission engineers are organized in 6 areas and 3 sub-areas, controlled and supplied from a headquarters at Lagos, as shown in Fig.2. These engineers undertake the maintenance of all the VHF radio, telephone channelling and VFT equipment in their stations; their responsibility commences at the audio points on carrier equipments and send and receive telegraph legs on VFT equipment. Six diesel engineers maintain the diesel engines and generators in the system. There are also about 75 locally employed technical officers and technicians with a force of 100 miscellaneous staff, such as fitters, riggers, clerks and drivers, etc.

2 SYSTEM CONTROL

As described in the Introduction, failure of either radio path results in loss of Path II traffic, making prompt remedial action necessary. Loop-round facilities on the radio equipment allow for quick location of the faulty station, and engineers travel at any time in the day or night to carry out the necessary repairs. A large number of stations are located at spots difficult of access, often some three hours' drive from the main residential towns where engineers are stationed. Two stations are only accessible by railway, and a repair of a breakdown awaits the first available train. A breakdown at such a station can therefore result in an outage time of many hours. It has therefore been found worthwhile to employ technicians at some remote repeater stations, who are capable of carrying out minor repairs under the direction of engineers at the terminals.

On occasion a major fault occurs, such as a twin diesel set power failure or severe lightning strike, which fails a whole repeater station, putting both radio paths in the link out of service. In this case, the triangular pattern of the system (see Fig.1) allows for some traffic

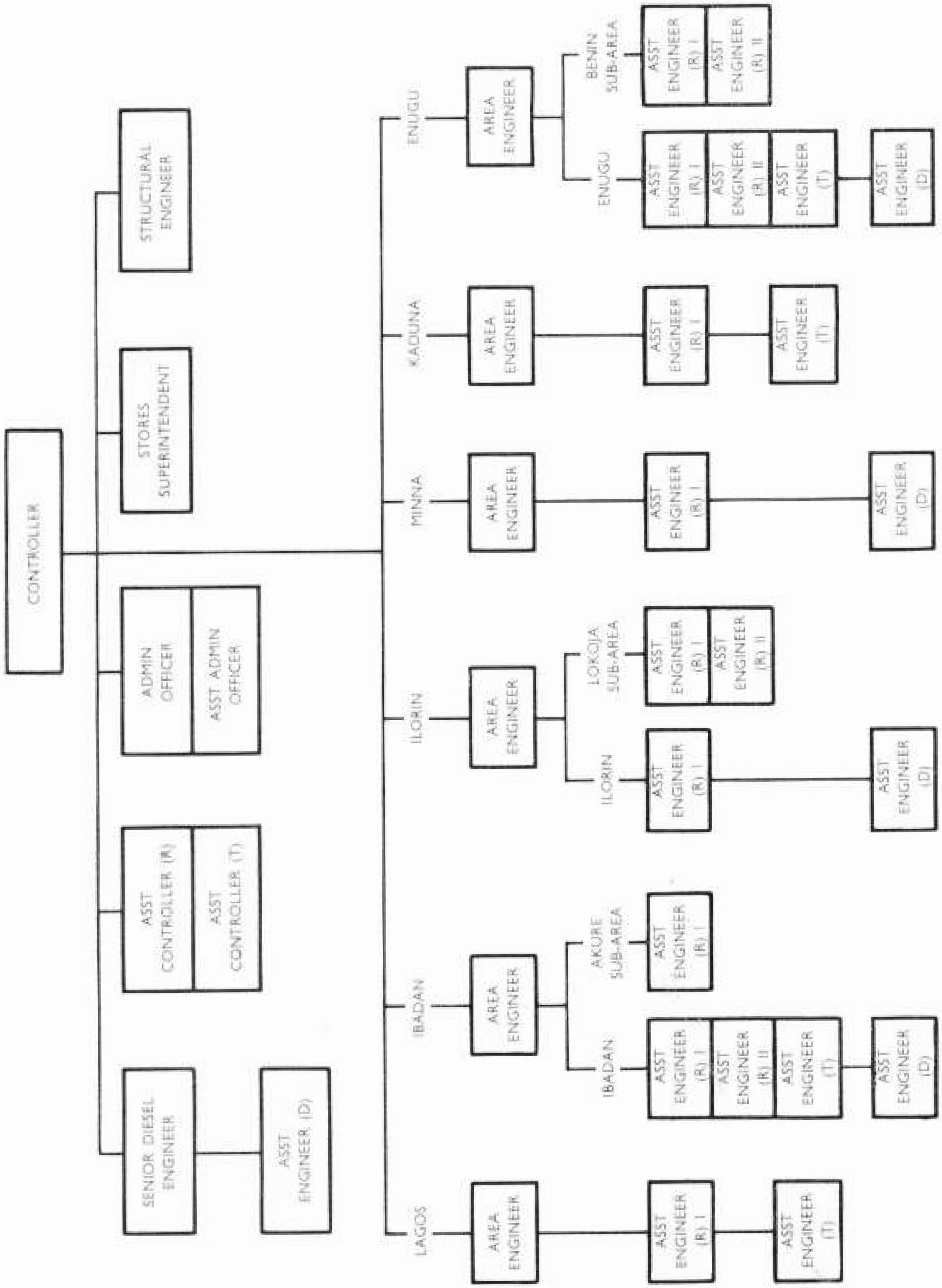
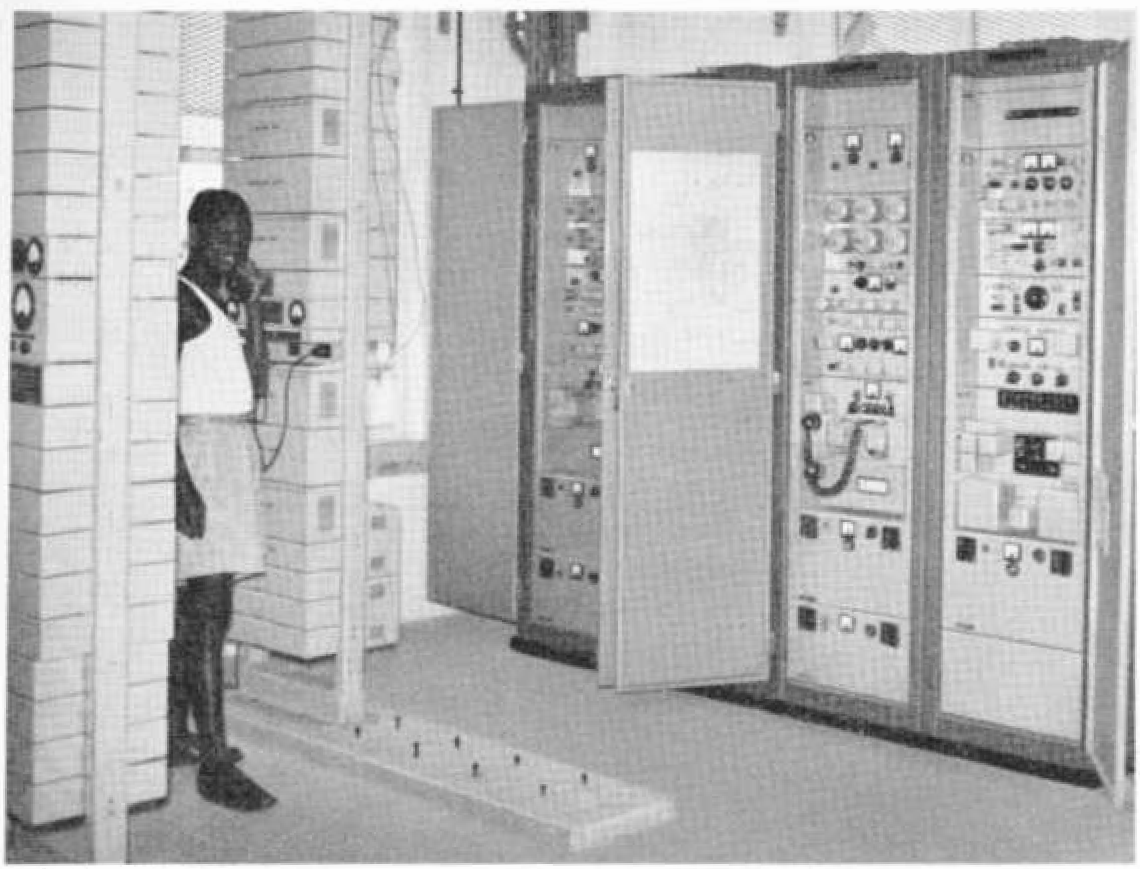


Fig.2. N.M.S Senior staff establishment

between the terminals concerned to be passed along the other sides of the triangle.

Fault control is vested in certain main controlling stations whose responsibility it is to supervise the clearing of the fault in the quickest possible time. They are responsible for the patching of priority traffic and VFT systems on to other routes as required, and keeping the local stations and exchanges informed of the situation. Controlling stations also advise Maintenance Service headquarters staff in Lagos of serious faults, who keep the P & T Department in touch with the overall situation. The carrier stations and headquarters are linked by telephone order wires so that rapid inter-communication is assured. Main carrier stations are staffed round the clock and an engineer is always on telephone call.



Typical terminal installation showing twin path radio and carrier equipment; provision for additional carrier equipment can be seen

All faults are recorded in a station log book, and also on fault dockets which are reported to the main Lagos control where they are analysed weekly. These dockets, a sample of which is shown in Fig.3, contain all the information on the radio fault and its clearance. (For simplicity in calculation, outage times are given in decimal parts of an hour.) It has been found convenient to classify faults into categories. This simplifies analysis and assists in tracing persistent faults in order to eliminate them in future. The breakdown adopted is as follows:

1 *Fading and 'FNF' (Fault not found)*	Possible radio fades and cases where no definite fault is found on investigation. (Faults in this category are often due to intermittent types of faults such as dry joints, bad valve pin connections, etc)
2 *Lightning*	Known lightning damage
3 *Rectifier valves*	
4 *Valves other than rectifiers*	
5 *Components*	Resistors, condensers, etc
6 *Radio equipment*	Radio equipment faults other than 3, 4, 5, 7 (e.g. stage off tune, meter switch faults, bad connections, etc)
7 *Fuses*	Fuses blown on radio equipment, possibly due to mains or lightning surges, etc
8 *Power supply*	Failure of mains supplies from diesel sets or town supplies
9 *Maintenance*	Planned maintenance work

3 RADIO SYSTEM PERFORMANCE

The radio fault analysis was begun in early 1959. Weekly posting of the information obtained keeps the staff up-to-date with the trends, but averaging over a longer term is more significant from the engineering viewpoint. Fig.4 illustrates one method of presentation of such data, giving average outage times per week, expressed as a percentage, for the four quarters of 1959 and 1960, broken down into the classifications given above. The data given in Fig.4 involves summation, of the outage time on each link-path (made up of two VHF terminals and a number of repeaters) for the whole system. The average outage time for the whole of 1959 was 0·87% (i.e, an average of 1·45 hours per week for each of the 18 link paths). The average for 1960 for the whole system (covering 16 links only) was 1·09% (i.e, 1·83 hours per link path). The percentage of time in this period for which any link was completely out of action, due to a fault which affected both paths simultaneously, averaged less than 0·1%.

Control Station

RADIO SYSTEM

FAULT DOCKET

SERIAL No.	SYSTEM FROM TO CHANS
DATE	DIRECTION FAULT REPORT:
TIME RECEIVED	FAULT DETAILS (Further details overleaf)
OFFICER DEALING	
TIME CLEARED	FAULT LOCATION: TERM/RPTR RX/TX
DATE CLEARED	FAULT CLASSIFICATION
DURATION HOURS —	
TRAFFIC LOST CHAN. HOURS —	
ENTERED ON FAULT ANALYSIS	
CHECKED	

FAULT CLASSIFICATION

FADING & F.N.F.	LIGHTNING	RECT. VALVES	OTHER VALVES	COMPONENTS	RADIO EQUIP.	FUSES	POWER SUPPLY	MAINTENANCE						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Fig.3

The fault analysis for 1959 and 1960 are shown in Tables 1a and 1b.

Table 1a
FAULT ANALYSIS, 1959

Total duration and number of faults (18 links)	*1382·0 hours*	*868*
FAULT TYPE	OUTAGE TIME (%)	NO. OF FAULTS (%)
Fading and FNF	23·4	30·2
Valves other than rectifiers	17·4	13·9
Radio Equipment	16·6	15·3
Fuses	16·0	17·4
Rectifier Valves	10·6	10·0
Power Supply	7·3	7·3
Components	5·0	3·1
Lightning	3·7	2·8

Table 1b
FAULT ANALYSIS, 1960

Total duration and number of faults (16 links)	*1524·0 hour.*	*977*
FAULT TYPE	OUTAGE TIME (%)	NO. OF FAULTS (%)
Radio Equipment	21·8	15·8
Fading and FNF	19·9	28·0
Fuses	18·5	19·6
Valves other than rectifiers	14·8	12·2
Components	12·2	4·7
Rectifier Valves	6·5	6·3
Power Supply	5·5	13·0
Lightning	0·8	0·4

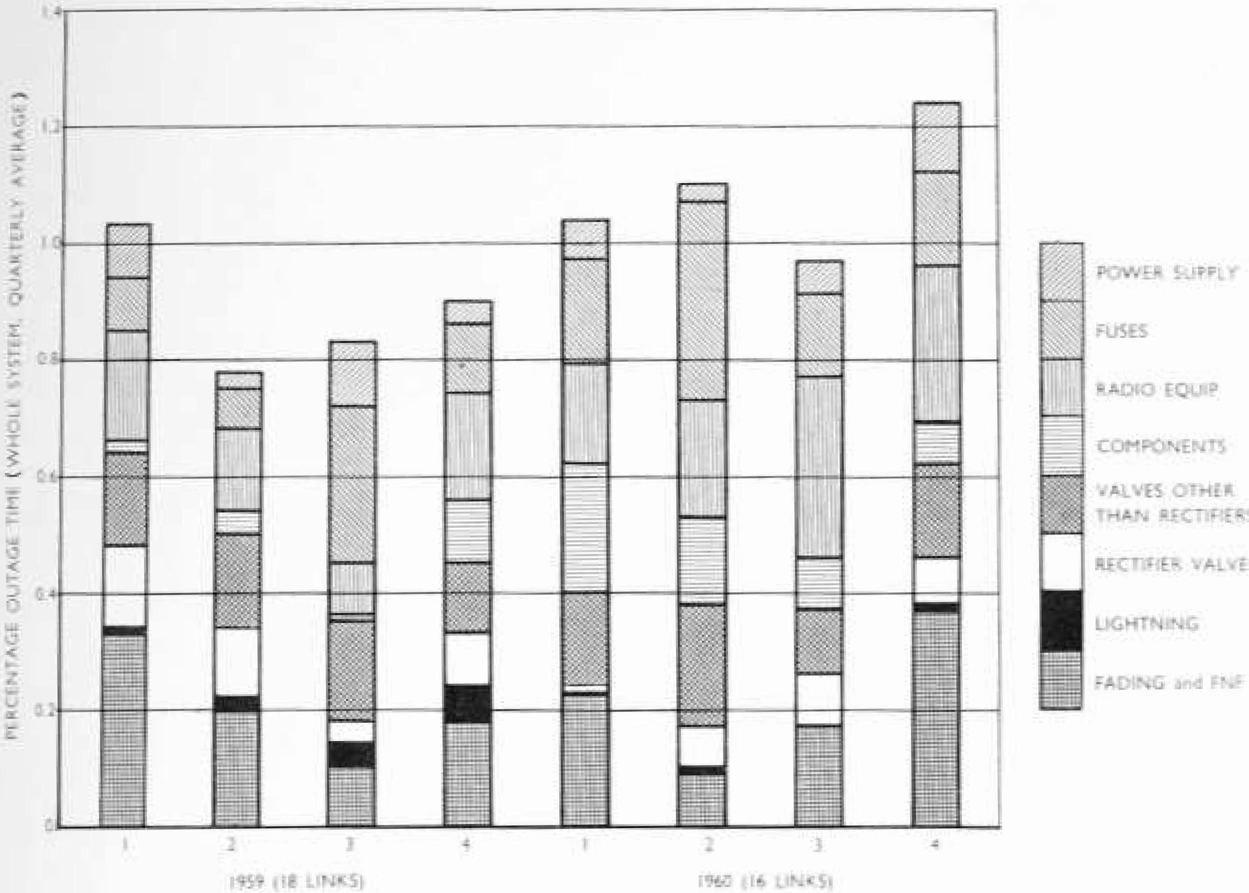
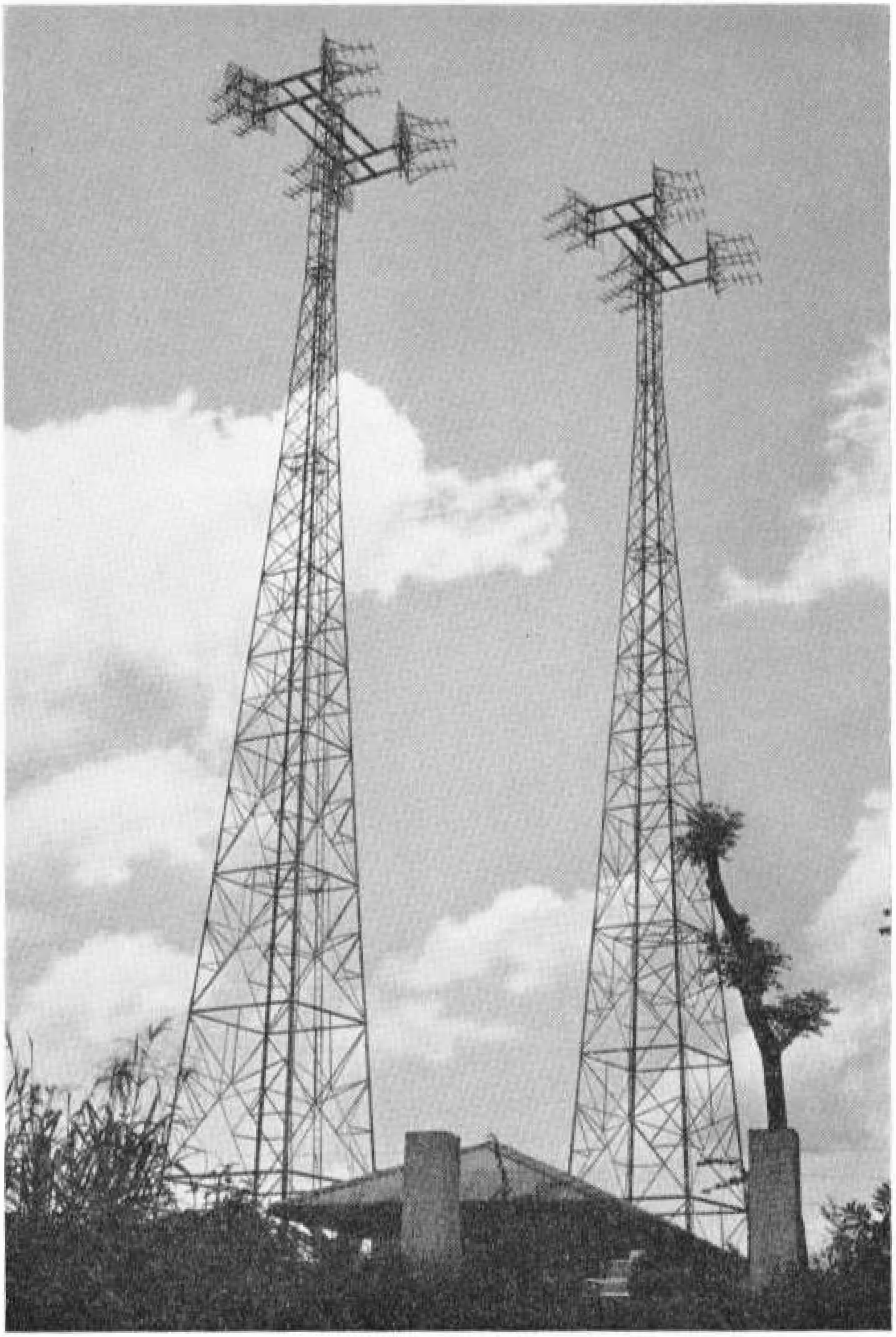


Fig.4. System average outage time (%)

Even before the fault analysis was begun, it was apparent that failure of rectifier valves was responsible for a high proportion of outage time. To overcome this the valves concerned were changed at three-monthly intervals (approximately every 2 000 hours). Nevertheless, some 15% of outage was still attributable to this cause in the first six months of 1959, so it was replaced by an alternative type, the Mullard GZ.34. This is giving more satisfactory service, and at present is only being replaced on failure, rather than periodically. If, however, it is noted that the failure rate of these rectifiers tends to increase it is proposed to replace them every six months at unattended repeater stations.

Towards the end of 1959, attention was directed towards checking



VHF repeater station at IFE, a site with good access and improving the earthing at radio stations and providing surge diverters to reduce the number of blown fuses. Earths were remeasured and improved where necessary; surge diverters were fitted to mast lighting cables, overhead power lines and in between the radio equipment and dual engine sets. Isolating transformers have been fitted to some mast lighting cables so as to reduce the possibility of lightning travelling down feeders into the radio equipment. As an experiment slow-blow fuses and later anti-surge fuses were introduced into a section of the system and finally throughout the system.

To reduce faults due to valves, other than rectifiers, and the radio equipment, a special inquiry is being made to see if any particular type of valve or stage is giving trouble. The first step towards tackling the most frequent type of fault (i.e. 'Fading and FNF') is to identify the links and stations worst affected.

From the viewpoint of the Administration, outage time, representing lost traffic and lost revenue, is the all-important yard stick by which the system performance is assessed. From an engineering point of view however, the type and number of faults is more significant. Table 2a gives a link by link breakdown of this information, from which the worst link in the system in 1959 was seen to be that between Minna and Lokoja. Of particular significance on this link was the fact that the average faults per link, classified under the headings 'Fading and FNF' and 'Radio Equipment' (7·3 and 3·9 respectively), were nearly twice the system averages for this classification. Path attenuation figures for this link are not notably higher than for others in the system, so that a high incidence of undiscovered intermittent faults was indicated. This supposition is supported by the above-average rate of faults in the radio equipment which have been brought to light. To improve the position, all the radio equipment in this link was carefully overhauled in 1960 and each panel withdrawn and inspected for bad joints, poor connections, etc. The stations in the link with the highest number of faults were tackled first. Other links with a poor fault rating and carrying most traffic will also be given a thorough overhaul. Table 2b gives the fault information for 1960.

Table 2a
FAULT ANALYSIS, 1959

Link-Path	*No. of twin path Repeater Sections*	*Types and numbers of Faults*								*TOTALS*	*Average per Repeater Section*
		1 *Fading and FNF*	2 *Lightning*	3 *Rectifier Valves*	4 *Valves other than Rectifiers*	5 *Components*	6 *Radio Equipment*	7 *Fuses*	8 *Power Supply*		
Minna-Lokoja	5	73	3	20	23	5	39	29	6	198	19·8
Enugu-Lokoja	3	40	1	14	10	—	15	12	44	96	16·0
Minna-Kaduna	3	23	2	7	13	2	16	23	6	92	15·5
Lagos-Ibadan	3	24	2	15	3	—	13	13	18	88	14·6
Ilorin-Minna	5	31	6	15	23	2	26	27	11	141	14·1
Ibadan-Benin City	4	37	1	5	15	6	11	15	9	99	12·4
Ibadan-Ilorin	3	22	4	—	7	3	5	11	3	55	9·2
Enugu-Onitsha	2	5	2	8	7	2	2	6	3	35	8·7
Benin City-Onitsha	4	10	3	3	20	3	6	14	5	65	8·0
TOTALS	64	265	24	87	121	23	133	150	65	868	
Average per Repeater Section per annum		4·14	0·38	1·36	1·89	0·36	2·08	2·35	1·02	13·5	

The average number of faults per link-path during 1959 was $\frac{868}{18} = 48{\cdot}2$

Table 2b
FAULT ANALYSIS, 1960

Link-Path	No. of twin path Repeater Sections	*Types and numbers of Faults*: 1 Fading and FNF	2 Lightning	3 Rectifier Valves	4 Valves other than Rectifiers	5 Components	6 Radio Equipment	7 Fuses	8 Power Supply	TOTALS	Average per Repeater Section
Enugu-Lokoja	3	50	—	8	17	4	21	12	18	130	21·6
Minna-Lokoja	5	71	—	11	29	8	36	48	11	214	21·4
Enugu-Onitsha	2	24	—	5	10	1	8	16	15	79	19·7
Minna-Kaduna	3	32	—	4	4	3	7	31	26	107	17·8
Ilorin-Minna	5	30	3	17	27	12	27	36	24	176	17·6
Benin City-Onitsha	4	25	—	6	15	13	29	17	12	117	14·6
Ibadan-Benin City	4	27	1	7	11	1	11	16	15	89	11·1
Ibadan-Ilorin	3	15	—	4	6	4	15	15	6	65	10·8
TOTALS	58	274	4	62	119	46	154	191	127	977	
Average per Repeater Section per annum		4·72	0·07	1·06	2·05	0·79	2·65	3·29	2·19	16·8	

The average number of faults per link-path during 1960 was $\frac{977}{16} = 61{\cdot}1$

After the improvements described had been carried out the number of rectifier valve faults had fallen considerably and faults due to lightning had almost completely disappeared. The number of fuses blowing for no known reason appeared to be increasing; the increase was checked in 1960 by the introduction of anti-surge type fuses, but this type of fault remains a serious problem. Usually the 500 mA HT fuse blows and this may be due to a component failure which recovers when the equipment cools down (for example a condenser resealing). At one station the usual valve type HT rectifiers have been replaced by metal rectifiers and it will be interesting to see if the number of fuses blowing decreases.

The number of faults per link increased substantially in 1960, and this accounts for the higher average outage time. This may be due to a greater component failure rate with age.

4 MAINTENANCE PROCEDURES

Previous sections of this article have dealt mainly with the performance attained, and the procedure adopted once a fault has occurred. The performance attained, generally satisfactory when considered in conjunction with the physical difficulties involved, is the result of carefully considered preventive maintenance procedures.

Each unattended station in the system is visited on an average once per fortnight by engineers for routine checks and inspection. Maintenance work involving interruption of traffic is normally carried out before 8.0 am or after 11 pm. The main maintenance effort comprises daily checks of Carrier and VFT channels in rotation so that each channel is tested once per week, supported by comprehensive 3-monthly and 6-monthly tests and alignment on all equipments; these being scheduled in detail well in advance. Copies of the schedules are passed to the Traffic Branches who are thus informed of the expected circuit interruption due to maintenance.

The maintenance tests are shown in detail in routine instructions prepared by the group specially for the purpose, and form the *modus operandi* for maintenance effort. Care is taken that these instructions are in a form suitable for use by technical officers and technicians. The results of the tests are carefully recorded on special test forms which tabulate the test and specify the expected results. Copies are forwarded to headquarters where, after checking, they are filed to form a continuous record of path and equipment performance. From these results, in conjunction with fault reports, headquarters staff may decide that a special overhaul or some replacement of components or equipment is necessary. By continuous maintenance and interest in the equipment, faults are prevented and outage and lost traffic time kept to a minimum.

MAIN TESTS ON EQUIPMENT

RADIO TESTS	PERIODICITY
Path levels on 80 kc/s pilot sub carrier	Weekly
Meter readings	Monthly
Cleaning of valve pins	3-monthly
Receiver gain, noise factor and received signal strength	3-monthly
Aerial standing wave ratio	3-monthly
Overall frequency response	3-monthly
Line-up of radio links for traffic	3-monthly
Check of feeders and aerials	6-monthly
CARRIER TESTS	
Meter readings	Weekly
'Speak and ring' check	Weekly
Channel and signalling levels	Weekly
Check of signalling receiver	Weekly
Carrier supply levels	Weekly
Group and radio levels	3-monthly
Signalling relays and distortion	3-monthly
Carrier leak check	3-monthly
Overall channel frequency response and noise level	6-monthly
VFT TESTS	
Meter readings	Daily and Weekly
Distortion check and adjustment	Weekly
Check of telegraph relays	Weekly
Oscillator levels	Weekly
Mark-space ratios	3-monthly
Check of channel panel and AGC operation	3-monthly
Channel send levels	3-monthly

Adjustment to channel panels, Lagos

Care of the diesel power plant is given particular attention, in view of its fundamental importance to the efficient operation of the whole system. Although this plant is capable of 1 000 hours unattended running, more frequent maintenance is considered worthwhile, the number of diesel engineers employed allows for fortnightly routine visits of inspection and the following programme of servicing:

Every 750 hours—Oil and injectors changed.

Every 1 500 hours (except as below)—Top overhaul.

Every 4 500 hours—Minor overhaul.

Every 9 000 hours—Major overhaul.

The provision of adequate and reliable test equipment has been found to be essential. Originally, the items in Appendix I were held at each terminal station, and were brought along from the terminals or controlling stations by the engineer as required for tests at repeaters. However, the amount of damage suffered by the test equipment in prevailing conditions of transportation has resulted in the provision of test equipment at most stations. The transmission measuring set and electronic telegraph distortion measuring set are, of course, only required at terminals and intermediate terminals. The latter equipment has been found to be invaluable in the checking of VFT performance.

More complex test equipment is held at a central point. This includes such items as white noise and harmonic measuring sets, for use during special radio overhauls, psophometers, millawatt test sets and recording decibel meters, for continuous level checks.

Sets of spare valves and components are held and maintained on stations according to carefully thought-out scales. These spares are held in quantity in the Main Stores for the system, where also will be found base spares and complete spare panels roughly on a 'one off' basis (i.e. one spare panel for each type of panel in use).

5 CONCLUSIONS

Some engineers take the view that over-maintenance can be as bad as under-maintenance, since faults may be caused by disturbance to the equipment. The author does not support this view and considers that only by continuous interest in the equipment can it be kept up to specification and faults prevented. The regular performance of routine tests also helps to keep engineers in touch with the equipment and improves their ability to perform rapid tests while fault-finding. As a result of experience, however, the intervals between routine maintenance operations are being lengthened to 6 and 12 months respectively on some good links, meanwhile keeping a careful check on outage time and number of faults.

The performance of the Nigerian system for 1959 may be expressed as an average outage time per link-path, comprising two terminals and several repeaters, of 0·87%, with a fault liability of 48·2 faults per annum (13·5 faults per repeater section from all causes). In 1960 outage time was 1·09%, and fault liability 61·1 per annum (16·8 faults per repeater section from all causes). The more important factor, the percentage of time for which both paths are out of commission, was 0·1%, an average of 10 minutes per week.

The fault rate indicates the technical state of the system. The outage time reflects this but gives also an appreciation of system efficiency, this efficiency depending on the ability of engineers to localize and clear faults, the effectiveness of staffing arrangements in providing quick restoration, and the accessibility of the radio stations themselves. System efficiency can also be expressed by the average restoration time per fault. In 1959 this was 1·59 hours, and in 1960 1·56 hours.

It would be useful to compare these performance figures with other national systems and types of radio equipment (for instance, those operating at UHF). In Nigeria a UHF link has recently been installed and a comparison of performance is being started. Similar attention is now being given to the analyses of faults on Carrier and VFT equipment in service.

The Nigerian scheme consists of a self-contained transmission maintenance service where the emphasis is on centralized direction and control of maintenance staff in the field. It regards the network as a transmission whole and does not split functions separately into Radio and Carrier. The staff comprises transmission engineers who are capable of looking after both. The vindication of this approach has been the request by the Posts and Telegraph Department that the Nigerian Maintenance Service should assume responsibility for all transmission equipment maintenance in Nigeria. This will involve responsibility for Carrier equipment in a further 100 stations.

The existence of a highly trained maintenance staff can be turned to advantage in the installation of system extensions. While the primary responsibility of the Nigerian Maintenance Service has always been the maintenance of the existing system, nevertheless quite extensive installation tasks have also been accomplished.

Acknowledgment

This article is published by kind permission of the Director, Posts and Telegraphs Department, Nigeria.

Appendix I

TEST EQUIPMENT IN GENERAL USE

1 Reflectometer
2 Valve Voltmeter
3 VHF Signal Generator
4 RF Power Meter
5 RF Test Voltmeter
6 Avometer Type 8X
7 Out of Band Signalling Test Set
8 Transmission Measuring Set
9 Telegraph Distortion Measuring Set

L. A. SUMMERLAND, born in London in 1922 and educated at Royal Liberty School, Romford. After the war he completed his technical training and in 1949 joined the British Post Office working in the Telegraph Branch of the Engineer-in-Chief's office, London. In 1951 he was seconded to the Telecommunications Department, Malaya, and later joined the permanent establishment there. He served in Malaya for seven years and during this period was in charge of a Communications District, and later a large Electrical Workshop. Finally he worked in Headquarters on planning, installation and maintenance of all types of Carrier and Voice Frequency Telegraph equipments.

In 1958 he joined the Marconi Company as Controller of the Nigerian Maintenance Service.

Training Technical Officers in Nigeria

F. R. J. LANGRIDGE, A.M.I.E.E, A.M(Brit)I.R.E

The Marconi Company was approached by the Nigerian P & T Department to establish and operate a Radio and Transmission School in Nigeria, to train potential Nigerian technical officers to the sub-professional technical level.

The Marconi Radio School described can, with suitable modification, be adapted to suit the needs of any country having similar training problems.

1 INTRODUCTION

THE EXTENSIVE DEVELOPMENT of the public Telephone and Telegraph service in Nigeria, described elsewhere in this issue, led to a radical departure from the pattern existing in the P & T Department. Previously the Engineering Section of the Department had consisted of a number of professional-grade engineers and a few technical officers, who were mostly expatriates, supported by a large number of Nigerian semi-skilled technical workers. The new radio network involved a large increase in skilled staff for effective maintenance, and to meet this requirement as far as possible from local resources would call for a large number of Nigerians trained at least to Technical Officer standard.

The existing departmental training cadre in Nigeria was considered inadequate for this task, and the Marconi Company was invited to establish a Radio and Transmission Training School within the departmental training system. Since 1956, when the Marconi training school started with one class of 20 students, the scheme has been increased in both size and scope, and the 1960-61 session will see some 140 to 150 students under training (see Fig.1).

The first fully trained students left the School at the end of May 1960 and have now taken their place in the Maintenance Service.

Until this training scheme can produce an adequate number of trained personnel the Company is under contract to maintain virtually the whole of the trunk telephone and telegraph network.

2 ENGINEERING REQUIREMENTS OF THE P & T DEPARTMENT

As has been mentioned, a large proportion of the requirement for trained staff is met by expatriates. To meet the need from local resources calls for three main categories of staff:

(1) Professional-grade posts are filled by students who either proceed overseas for several years and qualify abroad—principally in the United Kingdom—or by graduates from the Nigerian Colleges. Students of this type usually follow a modified form of post-graduate training with one or more of the companies supplying radio equipment. The Marconi Company offers such training to engineers in England.

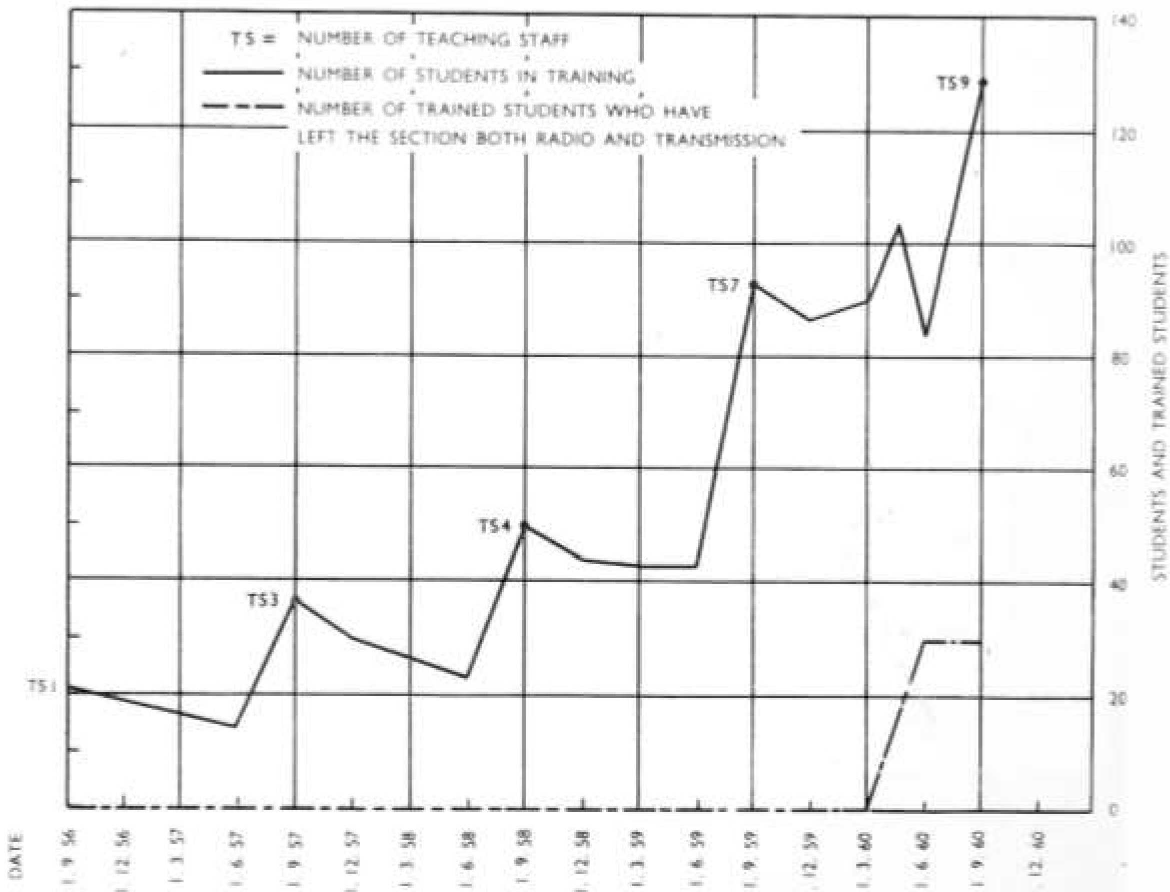


Fig. 1

(2) Technical officer posts. The scheme of training is designed to fit students to fill the many technical officer grades existing at the present time. The total requirement is expected to be between 175 and 200. The extensive radio network can provide adequate field training within the country. Technical officers required to fill vacancies for local line planning, automatic telephone exchanges, telegraph offices, etc, are trained elsewhere by the P & T Department.

(3) Staff required to fill the basic technical grade vacancies within the Engineering Department are given vocational training consisting of one or more craft courses of comparatively short duration, either at the Central Training School or one of the Regional Training Schools.

This article describes the facilities for training staff in the second category.

The Nigerian P & T Department Central Training School, Lagos

3 EDUCATION SYSTEM

As the recruits to the Marconi Radio School have to be selected from the output of secondary school students, it would perhaps not be out of place here to give an outline of the educational system current in Nigeria.

The population of Nigeria is some 35 million people. School attendance is not compulsory and, in fact, the school population is relatively small compared to the actual number of children of school age. Until recently, education at most primary schools was not free. Now in certain Regions of Nigeria free primary education is given, but it can take anything up to six years to reach the standard required for the 'Primary School Leaving Certificate'.

After the primary school stage a small proportion of students enter secondary schools. Education at secondary schools is not free unless the student can obtain a scholarship. Many of these scholarships are offered by the various Regional Governments and large commercial organizations. After four years at the secondary school the student normally enters for the West African School Certificate, which is equivalent to the British General Certificate of Education, ordinary level. The approximate numbers of boys taking the West African School Certificate is given in Table I.

Table I

Year	*No. entered*	*Total passes*	*Grade I Cert.*	*Grade II Cert.*	*Grade III Cert.*
1954	2,200	1,430			
1955	2,400	1,600			
1956	2,850	1,900	15%	42%	43%
1957	3,100	2,070			
1958	3,410	2,280			
1959	4,100	2,750			

Holders of the West African School Certificate may proceed to higher studies either in Nigeria or overseas. The number of secondary schools having Sixth Forms, in the U.K sense, is small and to ensure that there are sufficient candidates to proceed to degree level, the Universities and University Colleges of Nigeria hold courses leading to the intermediate degree examination. Even so, there is still an unsatisfied need for training to intermediate degree level and the Federal Government has established an Emergency Training Centre for this purpose. There are also Technical Institutes which accept School Certificate holders for their senior courses. The number of these Technical Institutes is inadequate and the total capacity at present is of the order 100 to 150 students per year. The range of subjects offered is accordingly restricted, and no facilities for training in radio or electronics are at present available.

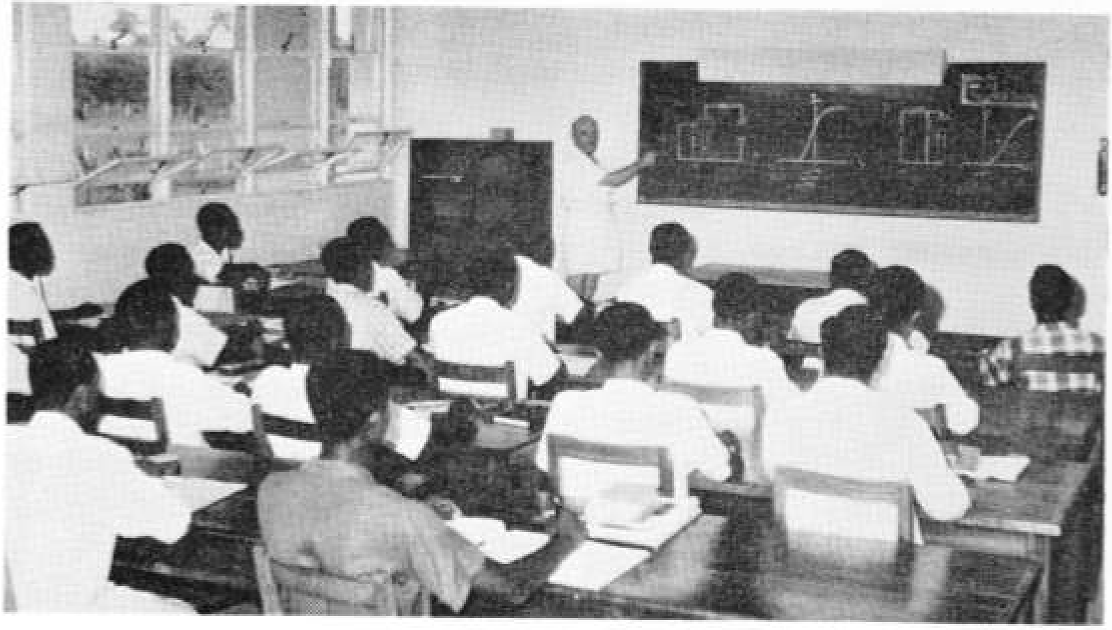
The method of entering the Universities is either by competitive examination or interview only. The tendency is, therefore, to sift off the better qualified student at the School Certificate level. This is, however, not always the case because unless the candidate has a scholarship, the University fees have to be found. Students can also enter the various Technical Institutes, and after a two years' course of study obtain the West African equivalent of the U.K Ordinary National Certificate. In addition, certain Government Departments have training schemes, and the Marconi Radio School is, in fact, a part of one of these.

Until comparatively recently secondary school leavers tended to avoid technical occupations and have taken clerical positions. The development of Nigeria technically has been recent and very rapid, and contrary to the known opportunities of a clerical career the Nigerian has not had any real idea of what a technical post would entail and what prospects it would offer. The rapid increase in technical development has, of course, increased the number of technical vacancies occurring each year.

4 SELECTION OF STUDENTS FOR P & T DEPARTMENT

Candidates are expected to hold a School Certificate, and to have reached credit standard in a Science subject, Mathematics, and—if possible—English. This is a minimum requirement and usually means that the applicant has to have a Grade I or Grade II Certificate.

In addition, opportunities are afforded to suitable members of the lower grades in the Department who are without a West African School



Typical lecture in progress

Certificate. The total intake for the P & T Department Engineering Training Scheme is 100 to 110 students per year, of which half are admitted to the Marconi Radio School.

5 TRAINING OF TECHNICAL OFFICERS

The requirement is to produce technical staff capable of maintaining UHF, VHF and HF radio communications systems and transmission equipment without constant supervision. The technical and practical skill of the trainee when he leaves the Training Centre must therefore be of a reasonably high standard, and the training scheme is designed to give a balanced theoretical, practical and workshop course.

The main course is spread over a period of four years, and comprises four nine-month sessions at the School. Following each session, the students proceed on field training for experience of station practice to give them some idea of the communications system as a whole.

The syllabus for the first three years is kept as broad as possible; this enables other organizations to make use of the training facilities.

Since there is no other form of established radio training to a satisfactory standard in Nigeria, requests for training radio technical staff are constantly received, and the P & T Department have allotted a number of vacancies to the Meteorological Department (Storm Warning Weather Aids), Cable & Wireless Limited (International Communications) and the Nigerian Police Force (Security HF and VHF radio networks). The main theoretical part of the course is completed within the first three years. Almost all the fourth year is spent on equipment and field training.

The students when they come to the Radio School have very little or no engineering background and it is, therefore, necessary to include in the general syllabus subjects which will broaden their general engineering knowledge.

In the school year of nine months, each week is divided into 31 one-hour periods. The weekly programme for each year is split into lectures, laboratory and workshop periods.

5.1 FIRST YEAR

The annual intake to the first year is 50 students, divided into two equal streams following the same syllabus, and throughout the year the two courses are held in step.

Owing to lack of facilities very little practical work is done at secondary schools and, therefore, the laboratory programme is extensive. Experiments are written up on cards in the normal way. A considerable amount of time is spent on basic wiring of both radio and telecommunications circuits. To stimulate interest the manufacture of simple printed circuits is undertaken and the students are afterwards introduced to the techniques involved in working on them.

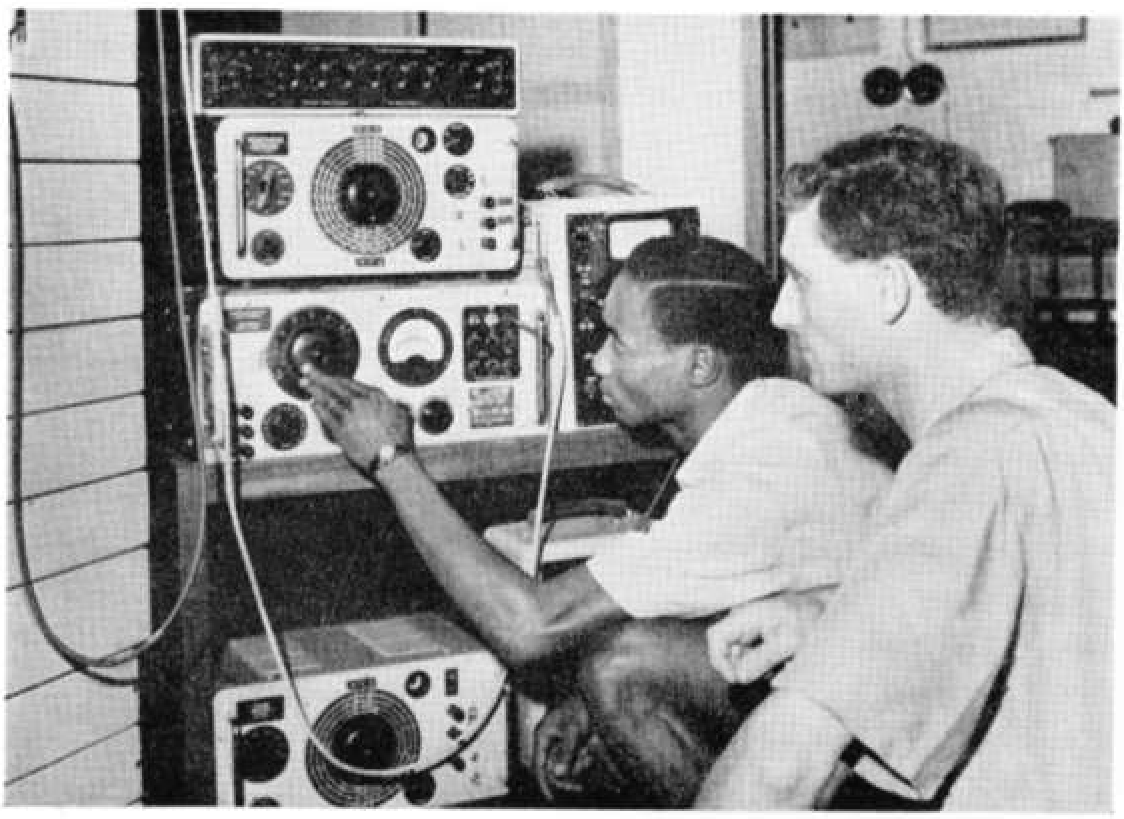
5.2 SECOND YEAR

The second-year students are in two streams and once again little distinction is made. At the end of the second year an adequate standard in Physics is reached and the students will have done some sixty to seventy experiments.

Drawing is continued until the end of this year. Naturally, the standard reached is not high, but it is sufficient to give the students a basic appreciation of working drawings, wiring and schematic diagrams, etc. At this stage an endeavour is made to co-ordinate between different subjects. For example, students draw a chassis in the Drawing Office, make and drill it during Workshop periods and complete it in the Radio Laboratory ready for electrical testing. The laboratory experiments attempt to make the student think for himself and draw logical conclusions from the results of his practical work.

5.3 THIRD YEAR

During the third year, the main theoretical part of the course is virtually completed. An additional subject, heat engines and standby power plants, is introduced, as in many remote areas of Nigeria there is no electric power supply other than that supplied by diesel-alternator plant at the radio stations.



Technician under instruction while carrying out tests on channel baysides

A split is made during this year between the two streams of students. One stream is ultimately destined for the maintenance of UHF, VHF and transmission equipment, and the other for the maintenance of fixed low and medium power transmitters and receivers and VHF fixed and mobile radio security networks.

5.4 FOURTH YEAR

This year is devoted almost entirely to equipment training. The lectures are mostly on equipment design, layout and familiarization. During the practical periods, the students are taught routine and station fault procedure, general line-up procedure, installation methods, etc.

5.5 FIELD TRAINING

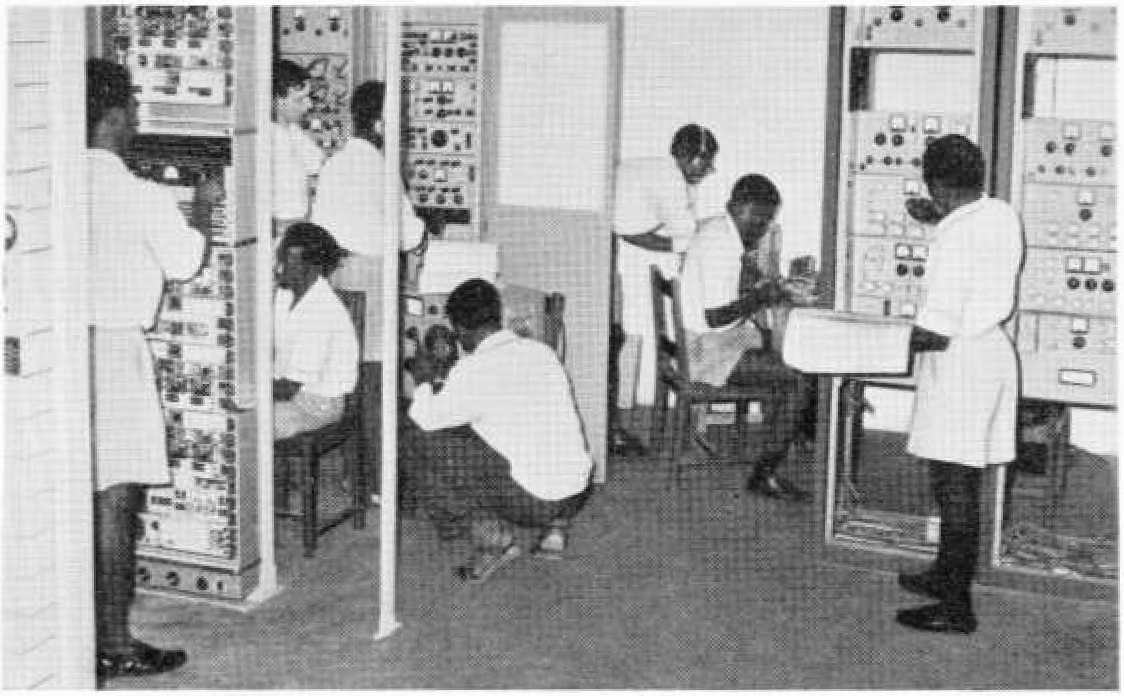
During the course there are three three-month periods of field training. Students are posted to different stations, no student being posted to the same station twice. This procedure is very useful because students come into contact with the duties they will be eventually employed on, and may also work at the station to which they will be finally posted. The field training effort was, in the initial stages, hampered by the lack of suitably trained local staff in the field. This is now being overcome as the number of trained students leaving the School increases.

5.6 FIRST YEAR AFTER COMPLETION OF TRAINING

A record is kept of the students' progress after they have left the Training Centre. Regular reports submitted from the various maintenance stations give a very good idea of the precise nature of the duties of the former students, and enables emphasis on particular equipments to be made at the Training Centre, particularly during the final year of the students' training.

5.7 LINE TRANSMISSION TRAINING

The introduction of new and more modern types of line transmission equipment has made it necessary to hold refresher courses of six to seven weeks' duration for staff already in the field. During each session one basic Carrier Course of six months' duration is also held. It is anticipated that students attending this course will have to return later to the



Final year students working in one of the equipment rooms

Training Centre for additional courses on specific types of equipment and systems.

6 WASTAGE OF STUDENTS

For an annual intake of 50 students, it is anticipated that at the start of each of the succeeding years the pattern will follow the figures shown in Table II.

Table II

First Year	Second Year	Third Year	Fourth Year
50	38	34	30

Students entering the School are not bound in any way and they are free, after a month's notice, to leave and go where they choose. This results in a heavy loss of students during the first year and part of the second year. As selection is limited to the better students, many of whom join with a scholarship application outstanding, it is not unusual to lose up to 10% of the intake within two months of the start of the first session.

Losses of students also occur due to failure. Careful selection ensures that these are comparatively rare during the first year. With the increase in tempo during the second year several of the weaker students fall by the wayside after failing in progressive weekly tests. By careful control of progress in the second year failures in succeeding years are kept to a minimum.

Losses at the end of the third year are almost entirely of outside students who do not require equipment training in the fourth year.

7 PERFORMANCE STANDARDS

The students pass or fail on results from both written and practical work. However, successes have been gained by students from the School in external examinations. Several of the better ones pass the General Certificate of Education examination in Physics (Advanced level) at the end of the second year. Some obtain the City and Guilds of London Institute *Telecommunications Technicians* Certificate at the end of the third year. It is anticipated that practically all the students leaving the School after the fourth year will hold this qualification. Some should approach City and Guilds Full Certificate level. Entries for other examinations are expected in the future. It should be emphasized that the syllabus is not specifically designed for these examinations, but the P & T Department encourage students to enter by rewarding success.

The standard reached at the School, which is proved by results in external examinations, is approximately the standard expected of this type of trainee (i.e. the Technical Officer) elsewhere in the world.

8 ULTIMATE PROSPECTS FOR TRAINEES

The policy of any country must be to man its own essential services by people from that country. This training scheme is designed to provide sufficient numbers of highly skilled Nigerian technical officers to staff the various radio and carrier stations throughout Nigeria, at present maintained to a large extent with an expatriate staff provided by the Marconi Company.

The opportunities and prospects for students are excellent. There has been no other radio training in Nigeria and these students—with the exception of a handful of technicians who have been trained in the United Kingdom—are the only persons who have had formal radio training at this level in the country. The vacancies existing within the P & T Department are many. There are also opportunities for trained personnel in the Nigerian Broadcasting Service, Western Region Television and various other Government Departments and commercial organizations.

A typical workshop

9 CONCLUSIONS

The types of training given by this scheme serve to fill the gap between the engineering graduate and the unskilled and semi-skilled grades. A well-trained cadre of local technical officers should ensure the smooth running of the various radio and transmission systems within Nigeria, providing at the same time candidates for eventual promotion to the higher technical posts within the Department. Future teachers for the Training Centre can be selected from the most suitable trainees when it will be possible for the expatriate staff gradually to be withdrawn.

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The writer wishes to express his appreciation for permission to publish this article to the Director, Posts and Telegraphs Department, Nigeria.

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