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INTERCOM

The Journal of the Home Office
Directorate of Telecommunications

Number 1
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'Telecommunications means any transmission, emission, or reception of signs, signals, writing, messages, and sounds or intelligence of any nature by wire, radio, optical, or other electromagnetic systems.'

Contents

THE DIRECTOR

W P Nicol

Photo: W. Stringer.

One talks of 'launching' a magazine much as one refers to the committing of a ship to the deep and, indeed, the analogy is not misplaced, for both occasions call for a blessing and, inevitably, to a certain sense of exhilaration, a feeling of accomplishment and, at the same time, some slight misgiving, that some small detail in the blue-print could be faulty or that the balance of the vessel will not be perfect.

I am only too aware that the creation of a journal such as this does not have so clearly a defined goal, for example, as that of scientific research or the meeting of an operational requirement by a design engineer, for what different readers of Intercom will hope and expect to find within its covers will undoubtedly extend over an enormously wide range. What should be remembered is that, first, it is a magazine published by a government department and therefore, in spite of disclaimers to the contrary, any opinion stated in it by an individual author will be thought to emanate from authority and, second, that most of the contents have been written by men heavily committed to their normal duties and with little time to spare for journalism. My first thought is, then, to thank them for devoting their time and energy in helping to bring Intercom into being.

My second thought is the aim of the journal and the very real need for it which originally made me consider creating a medium of communication for the Directorate somewhat less formal than official letters and circulars. The need was widespread and I was faced with the peculiar fact that people engaged in the art of communications are themselves not necessarily good communicators. There were sections of our organisation which were not fully aware of problems faced by other parts of the Directorate; there were customer Services which were not acquainted with the capabilities of the Directorate and how we saw the shape of Home Office communications in the future. There was generally a lack of a medium of discussion and information of the possibilities which lie before us.

My aim, however, has been not only to make good these omissions, but also to reach further and to make known to interested parties overseas what we are accomplishing, in what direction our researches into new methods and techniques are taking us, and the scope and quality of the equipment which can be offered to them by the British radio industry, which has had its efficiency demonstrated under operational conditions by the Home Office.

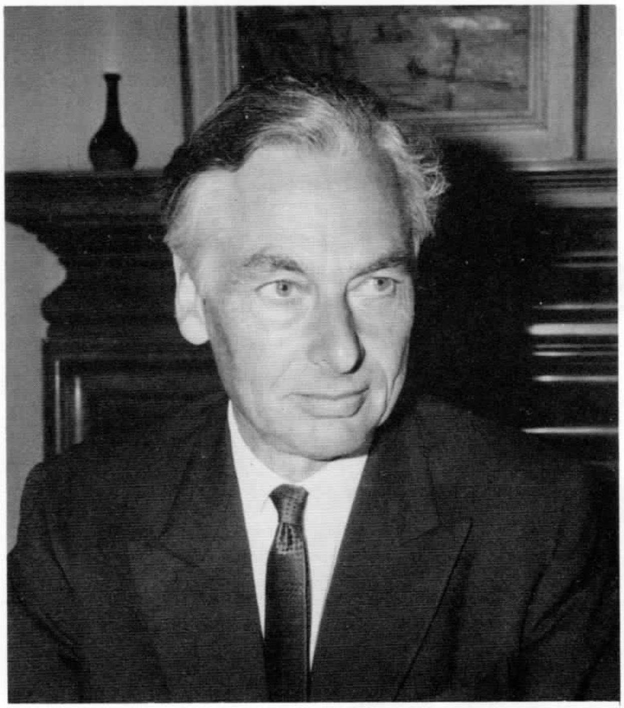
I would hope that, in time, besides receiving contributions from members of the outstations of the Directorate, that we shall be able to publish material from members of the Services whose communications needs we endeavour to supply. I therefore give this new venture my blessing and wish it long life and success.

THE LEICESTER EXHIBITION 1971

Engineers, technicians, and fitters arrived at Leicester University for the 1971 Home Office Directorate of Telecommunications Exhibition during the afternoon of Friday, 24 September, and through Saturday, Sunday, and most of Monday, a kind of organised chaos ensued, presided over by Ray Stoodley, officer in charge of the Central Communications Establishment, Harrow. If he was ever on the brink of losing his nerve he gave no sign of it. He marshalled his forces and brought pattern and design from their efforts. It was an impressive example of how an organiser's job is eased by the willing and enthusiastic co-operation of the rank and file. Everybody was determined that not only would the exhibition be ready on time, but that the results of their efforts would be first class. Co-operation between the Home Office and the industrial exhibitors could not have been better. Some of the latter came at short notice, but all made a good and colourful presentation with a clear description of their wares.

My most treasured recollection of the small part of the exhibition in which I was involved, was that at 1650 hours on Monday there was confusion all around me, but some 10 minutes later, when the official inspection was made, magical hands from Stanton Regional Wireless Depot and the Leicester Out-Station had brought about order.

On Tuesday, 28 September, Mr Richard Sharples, OBE, MC, MP, Minister of State, Home Office, opened the exhibition in the presence of Colonel R A St G Martin, Lord Lieutenant; Alderman P Watts, Lord Mayor of Leicester; The Duke of Rutland, Chairman of the Police Authority; Alderman W B Sercombe, Chairman of Public Control and Fire Brigades Committee, Leicester; Alderman E F Winser, Chairman of the Executive Council of the County Councils Association; Mr



The Minister of State, Home Office, Mr Richard Sharples, OBE, MC, MP, who opened the Leicester Exhibition.

J A Taylor, Chief Constable of Leicestershire and Rutland; Mr G E McCoy, Chief Fire Officer, Leicester City; Mr G K Lockyer, Chief Fire Officer, Leicestershire and Rutland; Sir Fraser Noble, Vice-Chancellor of Leicester University; Mr R R Thornton, Town Clerk of Leicester; Mr J B Howard, Assistant Under Secretary of State, Home Office, and Mr W P Nicol the Director of Telecommunications. It was the start of four days of useful and productive contact between the users and makers of Telecommunications equipment.

In his opening speech, Mr Sharples said: 'This exhibition has been arranged by the Home Office in collaboration with the electronics industry. It is right that it should be taking place at Leicester University, which has been justly praised for the excellence of its Engineering Department Building.

'The main purpose of the exhibition is to keep chief officers of the police and fire services, and their communications officers, in touch with the activities of the Directorate of Telecommunications and the industry. Also to keep them in touch with emerging ideas and possible future developments. It allows us to exhibit a variety of equipment and systems which are now available.

'Exhibitions of this kind require a good deal of effort both by the Home Office and the industry. I should like to thank all those who are contributing to its success. Particular words of thanks to Mr Nicol, Director of Telecommunications at the Home Office, who has been the moving spirit behind the idea.

'Although it was arranged at the request of chief officers themselves, I am particularly glad that we shall be having visitors from public security forces overseas. We are sure our public security forces are second to none. We are also confident that the telecommunications equipment and systems being provided for them are of the highest quality and should be of interest to visitors from overseas.

'Although this was arranged mainly as a domestic event for the Home Office and the services it supports, I hope that the opportunity will be taken to publicise the marketing aspects for police, fire, and other operational services abroad.

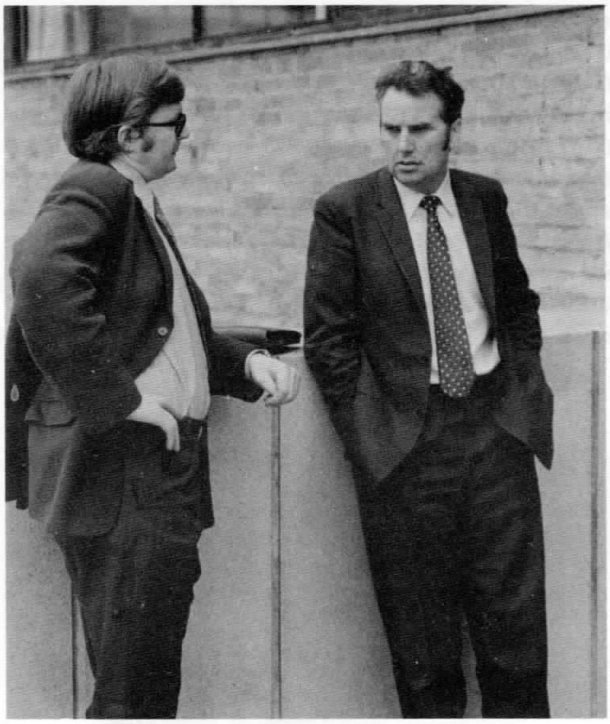
'The Home Office carried out a substantial reorganisation and expansion of the Telecommunications Directorate in 1968 and 1969. This had two objects. First, to strengthen the current engineering service to cope with the increasing amount and variety of equipment needed by the police and fire services. Second, to ensure that more attention would be given to future operational needs of the services in the light of future engineering possibilities. This requires extensive exchange of ideas between the services and the Home Office. It also needs close touch between the Home Office and the industry to ensure that the industry knows, and is responsive to, the future needs of the services.

D J Brown (Senior Communications Officer), John Brock (Fire Liaison Officer), and Ray Stoodley (Officer in Charge, Central Communications Establishment, Harrow) discuss a last-minute detail. Mr Stoodley was responsible for the layout and on-the-spot organisation of the Exhibition.

'This work has been carried on in a context of ever-increasing pressure upon the radio frequency spectrum. This arises partly from new users, such as local broadcasting stations. It arises partly from the increasing

use of mobile radio in the private sector—the current rate of growth in radio-equipped vehicles, excluding police and fire services, is about 15 per cent a year.

'It also arises from new operational demands arising from realisation of the value and necessity of good communications in present-day conditions. So it is essential that we make the best use of the frequencies available, and there is inevitably a demand for the technology to keep pace by devising equipment that will economise in the use of the spectrum. In this respect there are two research and development activities being carried out in the Directorate.



C J Theobald (Senior Wireless Technician, Weyhill) and Fred Catterall (Regional Wireless Engineer, Cranbrook) engrossed in discussion.

'First, a research contract with Swansea University for the study of modulation systems, which is looking very hopeful. There is a prospect that this will enable a reduction to be made in the band-width needed for radio channels, and also improve present multi-station radio schemes. The second is the work being done on the transmission by digital systems to and from radio patrols. The use of such systems could increase the efficiency of a radio channel by as much as a factor of 40. It may well prove suitable for ordinary routine messages of the kind that can get in the way of urgent tactical orders at present. A contract has been placed with industry for a study which will lead to a large-scale operational experiment in Birmingham and the four surrounding forces. This is a particularly interesting project, not only because of its geographical scope, but also because the use of a digital system opens up opportunities for automatic processing for such other purposes as command and control functions.

'The Police National Computer project, as you will appreciate, needs a considerable amount of communications—not only an extensive network of private lines, and terminals within forces, but substantial control equipment at the computer centre at Hendon. The Hendon computer centre is now in the last stages of completion and the main computer processors are due to be delivered in about three weeks' time for installation and testing. The communications system needed to control the national network is the subject of a paper at this conference, and I understand you will also be able to see a simulation of a working terminal.

'The exhibits include equipment, sponsored by the Directorate, that has proved of benefit to other Departments. There is, for example, new wide-band 10-channel mobile equipment that the Ministry of Defence are buying for the Provost Services, staff cars, and vehicles generally used for duties not requiring the full expense of battle equipment. This could, I think, be of considerable interest to overseas buyers for their public security forces. A mobile radio repeater unit developed for the Directorate is being used for the TA forces.

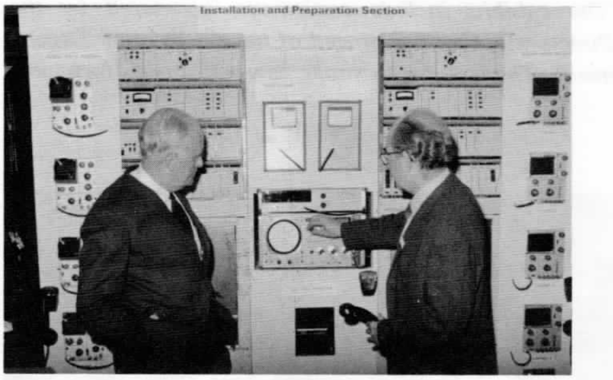
E W Crompton (Chief Wireless Engineer), V Petrovic (ITT attached University College, Swansea) and the Director discuss the double sideband diminished carrier project.

'You will also be told of development work on a new type of speedmeter, working on different physical principles from the present radar meters. This shows good promise and could be of overseas interest.

'I should perhaps mention the remote control systems in widespread use by fire brigades who operate mobilising schemes. It may not be generally known that these systems, which have greatly increased the efficient turnout of such forces, were sponsored by the Directorate and developed jointly with the Post Office by their engineers.

'You will also see four new types of personal radio equipment now being evaluated. There has been an enormous growth in the use of personal radio. There are now about 29,000 in use, and they have had a profound effect on the operational methods of the services, and on the efficient deployment of manpower.

'For the alerting of firemen by radio, we have a large programme in train. Some 600 schemes have been installed and 8,700 pocket alerters have been issued. These will produce considerably greater efficiency in turnout, apart from eliminating the use of sirens, which cause complaints from the public.



The Director in discussion with Harry Martin (Senior Wireless Technician, Installation and Preparation Section, Harrow) (photo: Norman Butler).

'The final general observation I wish to make is to stress the importance of a concerted effort—that is by the forces, the Home Office, and the industry—to see how we can apply technology to make the best use of manpower and assist in operational problems. A number of experiments are going on at the present time to test how far new devices can assist in operations: these are designed not only to test the equipment, but to get insights into the way it could affect how you do the job. We are doing this at present with facsimile transmissions to police cars and with mobile teleprinters. There are also experiments and studies in train on the subject of vehicle location systems.

'I know that you will find this exhibition interesting and instructive. You will find that there have been substantial developments since the last exhibition in 1968.

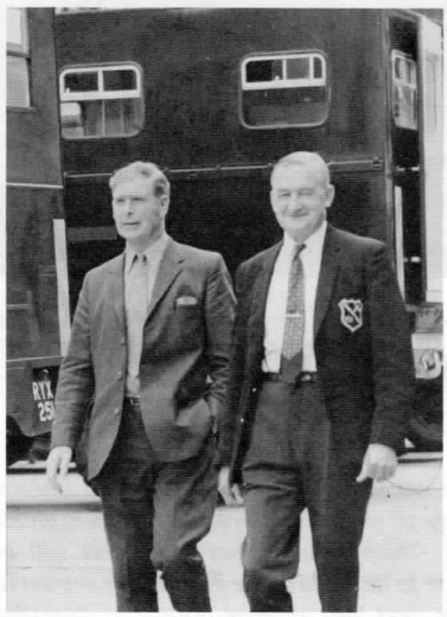
'I have pleasure in declaring the exhibition open.'

The Minister later faced some probing questions from the Press and, with the Director, reinforced much of what he had said earlier. On making his tour of the exhibition, he was impressed to hear and see himself making the above speech on video tape.

DIRECTOR SPEAKS ON RADIO

Later, the Director found himself at a moment's notice in the studios of Radio Leicester, answering questions from a BBC interviewer. The first question was why the Home Office thought it so important to stage the exhibition.

A: *Well, the Home Office, of course, in Central Government, is responsible for police and fire services of this country, although they are very largely local government activities in effect. And my own Directorate, which is an engineering organisation basically in the Home Office, provides all the research and development, the purchasing and procurement of electronic systems, and telecommunications systems for the police and fire. We install them, we maintain them. I suppose we're the kind of Corps of Signals of the business. And it is essential that the operational user, the policeman and the fireman and their engineering support services, are both in the closest contact and understanding. I think that it is well known today that your electronic wizard tends to go off into his little ivory castle by himself. So it's said. And the whole purpose of this is simply that we want to know what the user's real need is. The user wants to know what we can do for him. I think it's working. I think that's what it is about.*



A McFarlane (Stores, Harrow) and C Baker (Harrow) walking through the emergency vehicle lines.

Q: *You've had people not only from all over this country but from other countries along to the exhibition, so why choose Leicester?*

A: *Oh, well, I think the nice answer to that is that they're such nice people. I was here during the war and I* *have very pleasant memories of Leicester. But it's in the heart of England, it's very easy for people to get to, the university accommodation is just what we want, it has the right atmosphere, and I don't think we could have done better. I thank the Lord Mayor very much today for that, and the people of Leicester have been very kind to us.*

Q: *I suppose telecommunications equipment being used these days by the services is becoming much more complicated?*

Ken Shale (Technical Writer, CCE Harrow) and Andy Holstock (Senior Wireless Engineer, Field Services) take a well-earned breather.

A: *Yes—it's moving up. It was not very long ago when the policeman was either on his feet or on a push-bike on the beat and had no real communication with his headquarters except perhaps in some towns where, as you will remember, there was the old flashing beacon on the corner which alerted him when something was going on. Now, he's very much in continuous contact through his little personal radio. These personal radios are, in my view, one of the greatest break-throughs in the utilisation of communications that has happened for a very long time. It is invidious to pick out one system as the big important thing at any time, but certainly the personal radio application in forces like this, that is for the policeman on the beat or fireman on the fire-ground, often nasty places, this is really changing the whole way in which the job is done.*

Q: *Are the services keeping up with the new trends?*

A: *Yes, indeed. We embarked on a fairly major programme of development and change about four years ago and now we can see at the exhibition here, I think, the results of some of this work. Mobile communications to vehicles, for example, by radio has been going on for quite a long time, but this is now stepping up to quite a sophisticated degree. We can have voice communication to vehicles like the ordinary telephone, except that it is by radio, we have individual calling for the people we want or group calling, we can print messages into a vehicle like a teleprinter, as people call it, we can produce pictures in the vehicle, and all of this equipment is really necessary for a man who is in a car which is his working place if he's on a motorway or something like that. He needs a lot of information to be supplied to him and, conversely, he needs to take action. Two things about police and fire, you know, if you think about*

J Portanier (Senior Wireless Engineer, Headquarters) arrives at Leicester heavily laden (photo: Norman Butler).

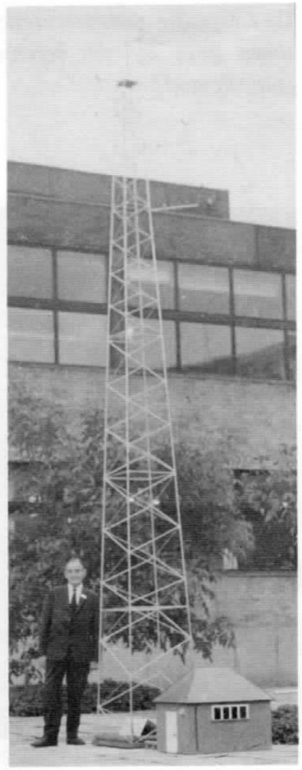
them quite simply—a fireman will always tell you that if he can get there quickly, he can deal with the fire and contain it. A few minutes is vital. The very same thing applies to the police world. We call it reaction time, and we're getting a very fast reaction time. The general public knows all about 999. Well, you can dial your 999 and you can get in contact with your emergency service, police, fire, ambulance, or whatever it may be, and we feel now that, with the radio being available to the policeman on the beat, you're getting him on your doorstep in something like two minutes. On many occasions I think this is important and must be comforting in many ways to the citizen.

Q: *It's perhaps a little bit early, but do you feel the exhibition has been a success?*

A: Yes, I do. You know, as I'm the chap who's responsible for running it, probably I shouldn't say it, but many people have been talking to me today. The operational police and fire officers who've been visiting from all the forces from all over the UK and from abroad have been telling me that they're taking a lot out of it, and that this is going to be very helpful to them when they return to their own headquarters to do their planning for the next stages.

Engineers working on Fire Service problems, consider that one of the primary requirements is an adequate paging scheme. The Directorate has this very much in mind, and two of the exhibits showed possible ways of meeting this need.

The Director says a kind word to some of the staff who helped make the exhibition a success. He is flanked by two of his Deputy-Directors, on the left by E W F Yirrell (Engineering), on the right by N Morley (Forward Planning and Research). To the extreme left is Ray Heath (Headquarters) who administered the staff side of the arrangements.



Sam Young (Senior Wireless Technician) standing beside his scale model of a typical Home Office Tower and equipment hut which stood in the fore-court of the University at the Exhibition (photo: Norman Butler).

THE HOME OFFICE CONTRIBUTION

There was a representative show of work and equipment from the Directorate itself which may be divided into five parts—equipment specifically for the Fire Service, equipment from the Test and Development Section, from the Field Services, Weyhill, from Bishop's Cleeve and from the Installation Section, Harrow.

For the Fire Service, there was an exhibition of the proposed Alarm by Carrier System; a dual alerter base station with auto-changeover; mobile equipment with dual receiver head to enable mobile operation on scheme frequency and, by switching, on pack-set frequency; a mobile equipment modified to operate in the transmission condition as a UHF to VHF repeater to provide mobile communications with control by an operator remote from a vehicle or applicance, using a personal radio UHF transmitter and small VHF receiver; and an Ultra pack-set modified for voice switching to hands-free operation for cliff-rescue purposes. Most of this work had been carried out at the Central Communications Establishment at Harrow.

The Test and Development Section from Harrow brightened their stand with a series of cartoons light-heartedly lampooning their work. They showed a signals selector; a size- and weight-reduced pack-set for dog-handlers, and a set-up for the single-manning of vehicle radio control.

The Installation Section from Harrow showed an inter-force communications system, illustrating communication between adjacent forces. They also exhibited a cabinet combining four 60-watt transmitter assembly units in a space normally adequate for one transmitter. Finally, there was a display of a Plessey 1 + 6 1100 Series, showing utilisation of six channels over one frequency link.

Field Services, Weyhill, showed a Time Domain Reflectometer for co-axial cable testing; Fluke equipment; closed-circuit television; the personal radio battery *capacity tester; a visual display unit; the PETA S350 series speedmeter modified to 100 mph; battery-charging equipment and reed-tester, and demonstrated teleprinter-to-teleprinter via a VHF radio link.*

Bishop's Cleeve exhibited personal radio and fireman alerter overall processing—ATE: Automatic Test Equipment for fireman alerter use.

Everyone who worked for the success of the Leicester Exhibition is to be congratulated. And here we must not forget the administrative staff who who did their best to cope with the not too easy task of looking after a large number of officials moving through an exhibition which took place in two separate buildings. Not only was an immense amount of work put into the organisation and the preparation and setting-up of the exhibits, but it was work that had to be carried on while the normal routine tasks of the Directorate continued. Such exhibitions, as we all know, are a strain on our limited manpower, but, at the same time, we feel sure that nobody is unaware of the great amount of good that comes out of them. Accomplishments unpublicised in the field of communications are accomplishments only half attained. The Home Office and the Industry showed unmistakably that together they are forward-looking and adaptable to changing circumstances and environment. The co-operation of the two sectors, public and private, was demonstrated in hardware and ideas to people who use them to the benefit of the general public and the country as a whole.

The Research and Development Section of the Directorate exhibited the new and exciting speedmeter being developed by Marconi on contract; Swansea University College showed the latest developments of their work on mobile radio. A breadboard equipment for a low frequency system for the Fire Service developed on contract by Plessey stood alongside the first results of the computerised survey. There was a small stand by Marconi representing the Mobile Automatic Data Experiment for which they are contracted.

The Director talks with Roy Vaine (Wireless Mechanic, Maintenance Unit, Weyhill) and Len Smith (Executive Officer, Headquarters).

During the exhibition there were a number of talks by members of the Directorate which covered a variety of subjects. Each day there was an open forum during which there was free discussion. The subjects of the talks were: Radio Area Coverage Systems, Control Room Systems, Communications Operational Requirements for Police and Fire Services, The Developing Pattern of Mobile Communications, Telegraph Message Switching, Communications Control System for a Central Computer, and Emergency Communications. A handbook of the exhibition was freely available which contained much of the material used in the talks with a great deal of extra information concerning the Directorate and its work.

PLANNING

Communications for Central Computers

P P H Smith

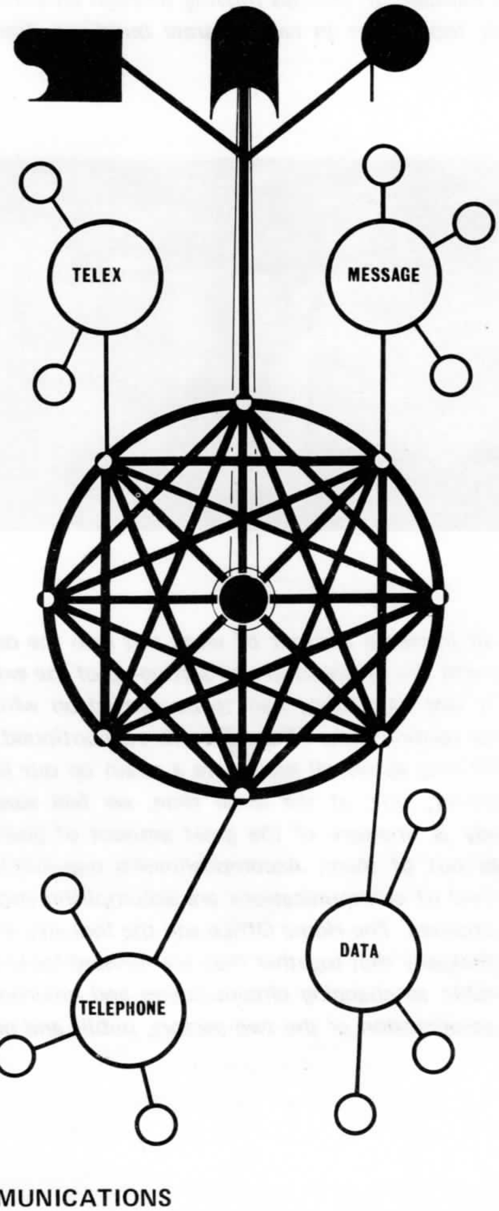
Paul Smith, CEng, MIEE, transferred to the Home Office Directorate of Telecommunications after some 30 years' service with the Ministry of Defence where he had been engaged on research and development, installation planning, and commissioning of strategic radio communications systems and associated radio relays. For the last 10 years, he has specialised in communications systems engineering, message switching, and long-term network planning. He is at present a Chief Wireless Engineer working on forward planning and research in line and data transmission.

For the purpose of this short article, central computers refer to those computers which are provided by a national, regional, or local authority for the purpose of providing a service to a number of organisations which could not individually justify such a service financially. They consist of data banks, or information files, records, etc, which are available for search, updating, and retrieval on the demand of any organisation having connected terminals.

Such a system is described as being 'real time' or 'or line', because the terminals are able to use the computer facilities at any time they desire with effectively an immediate response—which means that the response time is measured in seconds.

The majority of computer systems installed at present are not 'real time'. Processing is done in 'batches'. That is, the computer is set up to carry out one particular job, such as payroll, stock control, etc at intervals which are determined by the nature of the job, sometimes at regular intervals or when sufficient work has accumulated so that the setting up of the computer may be worthwhile. 'Real time' computer systems are more complex and, consequently, more expensive than 'off-line' or batch-processing systems, since the input to the computer is determined by the terminal user. This input can be at any time and may make use of one or more of a number of different programs. As the terminals are generally remote from the computer installation, communications are required between the terminals and the computer, and also between the terminals and the originators of requests for information.

It follows that an expensive, complex computer, capable of very rapid retrieval of information, is of little use unless the requests and responses can be transferred to and from the originators in an equally rapid and efficient manner. The 'system' must therefore be considered as a whole, and the efficiency of the whole will be limited by the weakest part of it. Response time will be governed by the slowest part of the system.



COMMUNICATIONS

The communications part of the system can be considered in two sections: (a) to and from the central computer and the remote terminals; and (b) to and from the remote terminals and the requesting/receiving point. The communications for the latter will vary from nil, when the user is operating the terminal, to a quite complex sub-system depending on the local geography, *administration, and need for speedy access to the computer facilities by various users.*

The communications for (a) will be comparatively standard for all terminals and must be designed to provide a reliability at least equal to that of the computer. These communications facilities having been designed to give the required standard of performance, means must be provided to ensure that standards are maintained in use, which can best be done by the provision of equipment to monitor and control the main communications network.

DESIGN CONSIDERATIONS FOR THE MAIN NETWORK

The first objective is to determine the operational requirement for the system as a whole. By this is meant such items as:

(a) type(s) of terminals;
(b) numbers of terminals;
(c) time-scale;
(d) locations of terminals;
(e) maximum acceptable down time of terminals, including their connections;
(f) maximum acceptable response time to terminals' requests;
(g) traffic patterns and loadings.

These items will determine the basic parameters of the communications system—whether a dedicated (private wire) network is justified, whether the public switched network may be used for all or part of the system, etc.

The network configuration will be determined by the type of line connection required, the reliability standards and consequent backup facilities needed. Response times and traffic loadings will determine whether terminals may share lines.

The design will always have as its aim the provision of the required facilities to the specified reliability standards at the minimum cost.

Part of the system will be the facility to control and maintain it, so this facility must be planned concurrently with the main communications network to provide the necessary quality control, flexibility of connection between lines and equipments, and testing capabilities.

MONITORING AND QUALITY CONTROL OF THE MAIN COMMUNICATIONS NETWORK

The purpose of a monitoring and quality control system is to

(a) ensure that the design standards of performance are maintained;
(b) restore service in the event of a fault or degradation of performance, in the shortest possible time;
(c) ensure that action is taken by those concerned to remedy faults;
(d) ensure that circuits and equipments are functioning to the required standards before returning to service; and
(e) anticipate the incidence of faults, wherever possible, and take action before the user is affected by degradation or loss of service.

The only place in the system where these functions can be performed is adjacent to the computer, since this is where the connections from the computer to the communications network have to be made.

To carry out the required functions, facilities must be provided to

(a) monitor and measure the quality of data signals to and from the computer;
(b) receive and act on fault reports from both computer and terminals;
(c) change connections to and from computer and lines;
(d) substitute standby equipment and lines for defective ones; and
(e) instruct the computer to take account of changes in the status of the network resulting from the above.

The facilities required are made available by the provision of test equipment, monitoring and test access jackfields, patching jackfields for flexibility of connections, terminals for engineering and direct back-to-back connection with remote terminals and the computer, 'on-line' terminals to the computer for reception of fault reports and transmission of instructions to the computer, and data switchboard for handling backup connections via the public switched network. It is also necessary to provide a fall-back system to pass information back to the user concerning major breakdowns of the main computer affecting all or a large number of terminals, independent of the computer.

The use of the computer itself to monitor certain aspects of the communications network performance has obvious advantages. It can be programmed to report to the communications control area when a terminal fails to respond, has an excessive error rate or is unable to pass an error-free message after a given number of retransmissions. It can also be programmed to analyse these reports; for example, if all terminals sharing one line fail to respond, this can be pointed out, thus saving valuable time in the communications control area. In this instance, there would be little point in investigating each terminal individually, and the controller would not first have to deduce that all terminals on one line were defective before taking action.

The last point supports the earlier statement that the system must be planned as a whole, and its various parts *should not be considered separately or thought to be of differing degrees of importance.*

TERMINAL TO USER COMMUNICATIONS

So far, the system response time will be seen to be limited only by the capacity of the lines connecting terminals to the computer and the processing time of the computer. Both of these have been determined by the operational requirement and not by design. No human action takes place in this part of the system.

The first human link in the chain is at the remote terminal, and it will have a very much longer 'response time' than the rest of the system. It follows that the fewer human links there are in the chain, the faster will be the overall response. Ideally, if speed of response is the overriding consideration, every user should have direct use of a terminal.

Where a user has need to access the computer only a few times during a day or week, this would be uneconomic and, for the majority of individuals in any one organisation, it will therefore be necessary to provide means of concentrating and distributing enquiries and responses from and to a small number of terminals in each organisation and their users.

Again, it is preferable for direct communication to be provided between the user and the terminal, since each human 'interface' or link in the chain increases the response time by a large amount compared with the basic response of the system from the terminal onwards.

Queuing of transactions at the terminal is inevitable, but the aim should be to keep this to a minimum and, when delays attributable to this become operationally unacceptable, the only solution is to provide additional terminals which can be put into service at peak load times and so make maximum use of the fast response of the rest of the system.

Where the type of transaction is of the 'one in, one out' type, an 'off-line' queue at the terminal is practicable provided the overall response time to the user is within the acceptable limit. By this is meant a written form of the enquiry which is dealt with by the terminal operator as it comes to the top of the pile or in any other order decided by the operational authority.

Where the type of transaction is of the question and answer, or conversational type—that is, the contents of a second or follow-up input is dependent on the response to the first input—direct communication between the terminal operator and the user will be essential. In this case, the local communications system within the organisation must be designed or supplemented in such a way that it does not of itself cause delays to the computer traffic required by the organisation in fulfilling its primary functions.

CONCLUSIONS

It is essential, when considering any real time computer system serving a number of organisations located away from the computer installation, that the computer and its various communications networks are planned as a whole, not in isolation.

In addition, where the system is not replacing a similar system but, as is usually the case, is a facility which is completely new to the organisations concerned, the communications facilities must be planned to be as flexible as is economically possible in order that they may absorb changes in traffic pattern caused by alterations in the number and structure of the organisations served. They must also be adaptable to the effects of changes in traffic loadings (suppressed demand) caused by the introduction of the computer to replace manual information exchange methods. The penalty incurred by incorporating such flexibility will be an addition to the initial cost which will be small by comparison with the whole. The long-term benefits will more than compensate by enabling changes and expansion to be absorbed with only minimal disruption of the working system and at lower cost than would otherwise be necessary.

TRAINING

THE PRESSURE OF OPERATIONAL NEEDS CREATES NEW EQUIPMENT. NEW EQUIPMENT DEMANDS NEW TECHNIQUES. NEW TECHNIQUES CALL FOR TRAINING.

The old attitude that training was a needless expense and a subject best ignored has long been discredited. Since the war the emphasis placed on training in both the public and private sectors has continued to increase and most organisations of any size now have separate training departments or branches.

If training is seen to be necessary for what we might call 'the pen and paper workers', it is equally necessary for men dealing with the complexities and variety to be found in modern telecommunications systems and equipment. The increasing demands of our customer services have created the need for the design and manufacture of sophisticated systems. The repair and maintenance of these equipments and systems have *challenged and will increasingly challenge the skill and knowledge of the men whose job it is to work on them. During the past year or so, the Home Office has let to industry contracts covering projects which, if successful, will extend to the limit the present capabilities of those now engaged on the test, maintenance, and repair of equipment. It has even been said that some of the telecommunications systems now envisaged will not only necessitate an increase in the capabilities of present technicians but will, in some cases, actually demand the creation of new skills and standards.*

To quote just a few of the projects undertaken by the Directorate, and which before long should be producing substantial results with wide-ranging effects, will give some idea of the situation we shall face in the years immediately ahead of us. The possible use by customers of data transmission, mobile facsimile, mobile teleprinters, double side-band diminished carrier working and the development of a new speedmeter based upon a different principle will demand a new expertise from the technical men dealing with them.

To go further, the outcome of the Mobile Automatic Data Experiment (MADE), which has been set up in the Midlands, may well result in the adoption of new computerised data equipment and all its attendant ancillaries. All of which shows plainly that the knowledge of the existing technical staff will have to undergo the necessary development to meet the changing conditions.

This is not the only aspect of the training of staff which has to be considered. There is also the problem of the training of men who have to deal with the day-to-day problems of repair and maintenance of what one might call conventional equipment—a real problem indeed. A fact which comes home to one when it is realised that there is a wastage of about 40 technicians each year.

These vacancies are currently filled by recruitment direct into the grade of Wireless Technician, but the wastage figures suggest that some weakness lies in this method. We are therefore considering the establishment of an apprenticeship scheme from which most technician vacancies can be filled in future.

The Training Section of the Directorate was set up in March 1970 to tackle the problem on both levels—that of ensuring that technicians entering the service will in future be of the necessary quality and that existing technicians will have the opportunity of gaining experience in the new systems before being asked to work on them.

The immediate and short-term requirements have demanded the establishment of a small school to provide training in subjects which can be carried out effectively and economically by our own staff. It is expected that the Directorate will have a substantial training requirement in basic logic circuitry and related requirements such as visual display units, message switching, vehicle location systems, and certain test equipment.

Although not fully staffed, the section has provided courses on Home Office Telecommunications Systems, courses which will continue through the year and which will later be modified to encompass the new equipment to be installed. The long-term result of this internal training programme will be not only the standardisation of techniques and performance, but also the raising of standards. Later, it is hoped that it will be possible to offer to our customer services short and informative courses which will play their part in both the dissemination of information and increasing the mutual understanding and appreciation of problems which are at present in the establishment and running of telecommunications systems.

A NEW SPEEDMETER

When the Directorate in 1969 started a review of speedmeters, the only equipment in use by police forces in England and Wales was the Marconi Portable Electronic Traffic Analyser Type S350, commonly known as PETA. This equipment is still in general use, and since its introduction in 1962 it has justifiably gained full acceptance of its claimed accuracy over its now somewhat restrictive speed range of up to 80 mph. However, although it is possible by modifications to extend the maximum measurable speed to 100 mph, and this has been done to equipments for motorway use, PETA has become somewhat outmoded in design, and by modern standards it is cumbersome in operation. It lacks certain desirable features such as digital speed read-out and print-out, a maximum speed reading of 150 mph, lane selection capability, vehicle counting, etc.

Although, as stated earlier, it is possible to extend the

PETA range to 100 mph by a reasonable degree of modification, to extend it to 150 mph would necessitate major circuitry changes. To provide digital read-out and print-out would require extensive and costly redesign. Even if these changes were made, a number of deficiencies would remain, and the equipment would still be unnecessarily inconvenient because of its size, its multi-unit format, and its need for large and heavy secondary batteries. Operational views obtained from the police confirmed a need for the introduction of a new equipment, which should be of compact proportions and simple in operation, as well as having the more comprehensive facilities already discussed.

The new traffic speedmeter being developed for the Home Office is accurate, reliable, and portable. It is expected that it will be capable of reading from 20 to 150 mph. The complete system is contained in a single unit, placed at the side of the road, with a view across the road at right angles to the traffic flow (photo: Marconi).

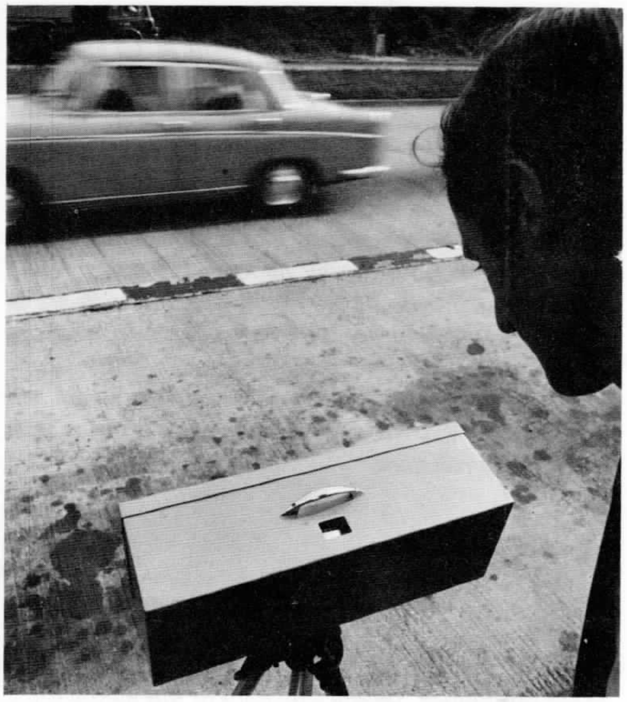
The introduction of a new speedmeter for legal enforcement purposes was not a matter to be undertaken lightly. Experience has shown that vehicle speed measurement is open to constant challenge, no matter how accurate and reliable the equipment has proved itself to be over a long period. PETA employs a doppler radar with squint-angle beam, and thus has the disadvantage of offering considerable scope for imaginative defence. A great deal of valuable time has been taken up in disproving claims of errors caused by postulated reflections from a limitless range of fixed and moving objects, not to mention allegations of interference from many sources including airfield radar, off-shore shipping, and electric trains. The selection of a new system, therefore, must not be influenced solely by its positive qualities of accuracy, reliability, convenience, etc, but must also take into account its susceptibility to or freedom from defensive arguments of the nature indicated.

When it was finally decided to go ahead with plans for a new equipment, a review was made of the field of firms capable of and willing to undertake the development required, and finally a development contract was placed with The Marconi Company. This followed a proposal covering a method of measurement based upon light reflection, the concept deriving from a system first devised by the company for measuring the speed of steel strip passing through a rolling mill.

The extreme portability of the apparatus being demonstrated. Heavy power supplies and connecting cables are totally eliminated (photo: John Lawrence).

During the course of development, which is now well advanced, a number of major and quite remarkable advances have been made from the original concept. These have had the effect of greatly simplifying the design and consequently of making it not only less expensive, more robust, simple to operate and maintain, but also more comprehensible to lay people—an important factor when considering its later operational use.

The speed range covered by the system will probably be 20-150 mph. The complete equipment comprises a single unit placed at the side of the road looking across it at right angles to the traffic flow. When a vehicle passes, its speed is indicated on a three-digit display on the instrument. The display will probably be of the liquid crystal type which is suitable for a wide range of ambient light conditions. Provision will be made to hold the readings for a predetermined time.



The whole device is small, light, and extremely portable, comprising simply the single unit mentioned with no cables or attachments of any kind. As it requires no transmitter and its design has avoided the use of any elements involving significant power consumption, the equipment's power requirement is minimal and easily provided from small internal batteries.

The equipment has yet to pass the model approval stage, following which it will be subjected to rigorous and wide-ranging operational trials. At present, however, there is every reason for optimism that it will more than fulfil its early promise and prove a very worthy successor to PETA.

Another view of this unique optical speed measuring system (photo: Marconi).

BONE CONDUCTION DEVICES

W. Stringer

There are many situations in which communications efficiency is severely impaired by the difficulty, sometimes apparent impossibility, of correctly positioning operators' microphones. It seems that in a large proportion of cases this problem may be nearing a solution—with the use of bone-conduction devices.

The bone-conduction device in question comprises a sensitive transducer which may be used either as a microphone, when it picks up vibrations from the larynx conveyed by the bone structure of the skull; or as a receiver, when it conveys audio intelligence via the bone structure to the inner ear. The device operates effectively in various positions on the head, but among the best for our purposes are the forehead and the sides of the jaw.

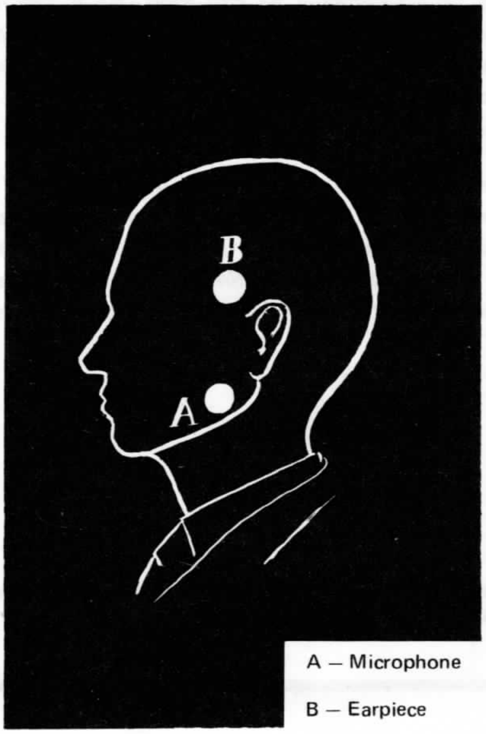
One long-standing problem of the nature described in the opening paragraph, to which as yet there have been only partial solutions, is that of the police motorcyclist's radio. The factors to be considered when providing radio facilities for motorcyclists 'on the move' are:

(i) personal safety;
(ii) the high noise level, from the engine and 'wind'; and
(iii) personal comfort.

The various arrangements which have been tried over the years have been of limited success for a number of reasons involving these three factors. Boom microphones attached to windscreens were unacceptable for reasons of safety and high noise level; throat microphones pose questions of personal comfort and inconvenience; and a skull-cap worn under the helmet was both uncomfortable on the head and its 'chin-strap' microphone tube chafed the rider's lip. While some of these compromise arrangements were acceptable to some forces—because they represented improvements over the basic situation of motorcyclists having two-way communication only when stationary—none of them was generally acceptable.

Recent work carried out at the Directorate's Central Communications Establishment (CCE), Harrow, gives hope that a system has been found which will be both efficient and acceptable to all operational users. This is based upon the use of bone-conductor transducers produced by Messrs McMurdo Ltd, and developed for their underwater equipment. A lot of work on similar devices is also being carried out at the Standard Telephone Laboratories at Harlow.

Preliminary work at CCE proved, quite remarkably, that even in the presence of a high ambient noise level of 90 decibels[1], speech from bone-conduction microphones is not noticeably degraded and the ambient noise is not transmitted. Tests have been carried out to find the best practical positions for microphones and receivers and it seems probable that, for the motorcyclist requirement, *attachment to the leather sidepieces of the helmet is probably the optimum arrangement.*



A – Microphone
B – Earpiece

Messrs McMurdo are currently working on reducing the size of their device, which at present is 1.2 inches in diameter and ¼ inch thick. It is hoped that it may ultimately be reduced to about one-third of its present diameter with the same thickness, while retaining its present high performance. The firm and CCE are also collaborating with Messrs Swift Aqua Supplies in the incorporation of the devices into a number of motor-cyclists' helmets, which will be loaned to police forces for operational trials. If the results of these trials are as favourable as preliminary tests have indicated, perhaps at last we can 'put to bed' this long-standing and pressing requirement for safe, comfortable equipment, which will provide motorcyclists with efficient and truly mobile radio communications.

Clearly bone-conduction techniques should offer benefits in many situations in which problems are posed by very high ambient noise levels or difficulties of microphone positioning. Several situations of this nature occur in the Fire Service, and consideration is already being given to the particular problem of communication with firemen wearing breathing apparatus.

[1] Extract from Noise Table.

Noise	Decibels	Relative Energy	Sound Pressure	Typical Examples
Painful	120	1,000,000,000,000	20	
				Jet aircraft at 150m
Deafening	110	100,000,000,000		Inside boiler-making factory
				Near pneumatic drill
				Motor horn at 7m
	100	10,000,000,000	2	
				Inside tube train
Very loud	90	1,000,000,000		Busy street
				Workshop
				Small car at 7m
	80	100,000,000	0.02	
				Noisy office
Loud	70	10,000,000		Inside small car
				Large shop
				Radio set–full volume
	60	1,000,000	0.02	
				Normal conversation at 1m
Moderate	50	100,000		Urban house
				Quiet office
	40	10,000	0,002	Rural house

THE DIRECTORATE

One fondly supposes, in full departmental conceit, that all of our readers—at least in this country—will know the purpose and responsibilities of the Home Office Directorate of Telecommunications. However, for the few who have never heard of us or others who have heard of us and do not know what we do, it may be as well to state that our main function is to ensure that all forms of telecommunications requirements of our customer services—fire, police, prisons, and civil defence—are met. The Directorate advises and assists authorities in Northern Ireland, the Channel Islands, and the Isle of Man. It also liaises closely with the Scottish Home and Health Department in communication matters relating to Scotland.

Members of the Directorate represent Home Office telecommunication's interests in Cabinet and interdepartmental committees and participate in the work of various study groups and working parties.

In carrying out its functions, the Directorate assigns frequencies in bands allocated to the Home Office; controls call-signs and operating procedures; designs and engineers new radio schemes; develops (in collaboration with industry), purchases, tests, stores, installs, maintains, and repairs communications equipment; and maintains in instant readiness, operational equipment for use in emergencies and for the setting up of communications systems under special conditions when required. On the lines side, it collaborates closely with the Post Office on the design and provisions of specialised line facilities. It also maintains all Home Office radiac equipment.

The Directorate is required to keep its books balanced, and to do so it assesses and recovers rental charges for equipment provided to its customer services and also costs and apportions installation and maintenance charges for work carried out. It has the responsibility to see that these charges are recovered.

STAFF

The staff of the Directorate, who are employed throughout England and Wales, consists of nearly 1,000 engineers and technicians, administrative, typing and stores staff, and industrial support staff. They are employed at the Directorate Headquarters at Rochester Row in London; at the Central Communications Establishment at Harrow; at three area headquarters; at 13 wireless depots and sub-depots, and at specialised maintenance units at Andover in Wiltshire and Bishops Cleeve in Gloucestershire.

The Central Communications Establishment comprises the Installation Section which plans, assembles and sometimes manufactures equipment before final test, and bears the shared responsibility with the appropriate Regional Wireless Engineer for the handing-over of a scheme to the customer. The Test and Development Section is responsible for the evaluation and modification of commercially produced equipment. It also prepares technical information and specifications and is responsible for testing all equipment provided by industry before it is offered to one of the services. The main stock of radio equipment held by the Directorate is kept at Harrow, at Weedon in Northamptonshire, and at Bishops Cleeve.

The regional wireless organisation is divided into three areas, with headquarters at Harrow, Birmingham, and Manchester. Responsibility for each area is vested in a Senior Wireless Engineer whose duty is to co-ordinate the work of its depots, to liaise with the customer services, and to act as the advisory contact between them and headquarters. From each wireless depot there are radio technicians detached to the workshops of various police headquarters. At the moment there are about 60 of these outstations, employing some 200 technical and industrial staff. The Maintenance Unit at Bishops Cleeve was set up for the specific purpose of maintaining police personal radios, fireman's alert receivers, and associated base stations. The Maintenance Unit at Andover maintains and offers engineering support facilities for closed-circuit television. It also evaluates, repairs, and calibrates test equipment and is responsible for the design and construction of special test equipment and facilities.

ORGANISATION

All forward-looking organisations must be capable of adapting to meet new circumstances, and the existing structure of the Directorate is currently under review, but at present it consists of three main divisions. Under the Director, W P Nicol, there are three Deputy-Directors—R J P Hayes in charge of the administration, N Morley in charge of forward planning and research, and E W F Yirrell in charge of engineering.

None of these sections is regarded as an independent entity and indeed it would be impracticable for so complex an organisation to function effectively if the dividing lines between the sections were not at times disregarded. The Directorate is a good example of the importance of the administrator being conscious of the requirements of the professional and of the engineer being conscious of the need of administration and good book-keeping. While an engineer is only too clear on the *subject of technical feasibility and operational requirement, the administrator faces him with the 'art of the possible' in terms of resources and policy.*

The Engineering Section looks after all the current engineering requirements of the Home Office and its associated services, police, fire, civil defence, and prisons, etc. On the subjects of field services, installation, maintenance and repair of equipment, and the telecommunications requirements for special events there is a close liaison between this section and the Administration Section.

Most of the Directorate's manpower is employed on maintenance of equipment. The work is carried out by the field organisation through its regional and special units, and every effort is made to ensure that maintenance is of the highest possible order. The organisation engineers are continually on the look-out for new methods which will enable communications systems to provide the most reliable service to the user.

The Administration Section is described adequately in its title; it is responsible for the whole of the staff organisation, for training, finance, and all administrative functions, including certain aspects of operational policy.

Finally, there is the newest section, that of Forward Planning and Research, a small part of the work of which is described in another part of this journal. In general, there are a number of interesting projects in hand which will no doubt be written up at the appropriate time. However, one should add here that working alongside the research and study project officers of this section are liaison officers from the fire and police services, who provide advice on operational procedures and requirements.

CLOSED CIRCUIT

The printed publication seems to have become the accepted mode of communication between the scientific and technological departments of government and other interested parties. The one-way declaration of intention, after due private discussion and agreement, on the part of a government department, the circular letter and the book of instructions are no longer the only means of conveying intelligence. It has been realised that communication must be two-way; it must form a dialogue.

The Police Research Bulletin *was first issued in 1967 and has become a clearing house of worldwide scientific and operational police knowledge. The need for a bulletin was shown clearly by the fact that its circulation trebled within a short time. Discussions between scientists of the Home Office and in the universities, between working policemen and other interested parties in all parts of the world has stimulated exchange of ideas and expertise.*

A similar need exists for the exchange of information and ideas about Telecommunication matters, both within the Directorate and between the Directorate as a whole and its numerous customer services.

It is hoped that INTERCOM will play its part in satisfying that need. Further, by going overseas to Commonwealth and foreign readers, it should act as a means of communication between government agencies with common interests—fire services, police forces, and other forms of public services which require facilities offered by telecommunications.

This first issue should be regarded as a preliminary run, a declaration of the magazine's existence, a statement of its intentions and what it will require to serve its purpose and perpetuate itself to the advantage of its readers. The magazine will no doubt undergo changes as it progresses. This first attempt is in some ways an extension of the literature distributed at the 1971 Leicester Exhibition and an attempt to inform people of the work of the Directorate and its aims.

It is therefore couched mostly in general terms, but future editions will no doubt tend to become more technical. If the technical parts become too much for the lay reader, perhaps he could follow the example of Somerset Maugham who was an unashamed skipper of passages which bored him. We hope, however, that INTERCOM will stimulate the interest of writers on the subject of telecommunications who may wish to see their material within its covers.

In the past, some information on telecommunications has been published in the Police Research Bulletin*— and rightly so, for there has been until now no other means of publicising certain aspects of the subject. In the future, there will be the closest co-operation between the editors of this journal and the Bulletin and overlapping should not take place, although at times it will be necessary to cross-reference one magazine to the other.*

There is no need, we feel sure, to impress on the reader the journalistic difficulties which arise when a magazine of this kind is planned. The main problem is at what level it should be pitched, at which reader it should be aimed, and how technical one should allow oneself to be. Many readers may find in this first issue much that they already know, but we do not apologise for this. Others may read the information for the first time.

Perhaps, in some small way, we shall act as a shop window for British products, for the Home Office does not lightly approve equipment for use by its customer services. The equipment has been evaluated by Home Office engineers and serving officers in the field.

The future of INTERCOM will depend to a large extent on the response of its readers. Comment, favourable or otherwise, is welcomed. Enquiries concerning any of the items mentioned will be answered as quickly as possible.

CIRCULATION

The initial circulation is of necessity a tentative one. We shall be pleased to add to the distribution list or to increase the number of copies sent to a recipient. A telephone call or letter to the Editor will ensure this.

PHOTOGRAPHS AND INFORMATION

The INTERCOM office is at present forming a photographic library of all aspects of telecommunications. We should be grateful for any help from our readers in this task. We are interested in both contemporary and historic pictures of equipment, of service members operating equipment, and of situations in which the use of telecommunications equipment played an important part.

It does not matter what form the photographs take—negatives, prints, transparencies: all will be of the greatest interest. For publication in INTERCOM, however, the ideal picture is a positive print; the magazine is produced by the photo-lithographic process. The most convenient size for a print is roughly half-plate, but all will be welcome.

So far as general information is concerned, we are interested in having either as reference or of publicising any original ideas which may have come into being in what, for the want of a better word, we shall call the 'field'.

THANKS

We thank the Editor of the Police Research Bulletin *for advertising our birth in a full-page spread in the summer edition of the 1971 Bulletin.*

Members of the Mobile Automatic Data Experiment (MADE) Study Group during a demonstration on the Marconi premises at Chelmsford. The visible faces from left to right belong to E W Crompton (Home Office Project Manager), Chief Inspector M A Collins (West Midland Police), Chief Superintendent P D Peterson (West Midland Police), Mr A G Wanklin (Birmingham Police), Mr P D Knights (Assistant Chief Constable, Birmingham), Chief Inspector J W Hughes (Staffs and Stoke Police). The lady is a Marconi engineer.

MOBILE AUTOMATIC DATA EXPERIMENT (MADE)

One of the major problems facing those concerned with telecommunications for the police service is the acute need to speed up the transmission of information between the control rooms and police vehicles. As voice message traffic continues to increase, police mobile radio systems are becoming overloaded and, in consequence, forces are asking for additional radio channels and increases in control room staff to handle the extra traffic. It is clear that there will come a time when these increases cannot be met, either because of expansion of the system would entail the extension of existing buildings and base radio stations, or because additional radio frequencies are not available.

Studies of the voice traffic on mobile police channels show that some 80-90 per cent of it is capable of definition in standard message form. The primary objective of the Mobile Automatic Data Experiment (MADE) is to find the best methods of coding messages—including mobile location studies—and exchanging them by radio in digital data form up to 80 times faster than transmission of corresponding speech messages. A reliable data transmission system of this kind will increase police efficiency and could reduce the present and future sizes of control room staffs.

Some useful data systems of this general type are of course already on offer from industry, but they probably do not go as far as is desirable in using data-handling techniques. In particular, they do not use a 'dedicated' data link—that is, one used exclusively for data traffic—nor very high data-handling rates.

A small demonstration button-box provided under the MADE contract to give the study group an insight into the kind of facilities that can be provided in a mobile. The lower button is for SOS purposes.

A MADE study group was set up in early 1970, consisting of Home Office telecommunications staff and representatives of the five police forces surrounding the Regional Wireless Depot at Romsley, which had been chosen as a suitable location for the experiment. Between them these five forces range from the largely rural to the completely urban, with different degrees of centralisation of control.

This study group will remain in being throughout the project, with the prime task of seeing that there is no disparity between the overall operational needs of the police and the engineering capability of the system. It was decided that the final aim of the experiment should be to produce standard specifications for elements of a data system, against which industry could tender to meet specific operational requirements.

To meet this aim, the experimental system is to be provided with a variety of facilities so that comparative assessment can be made to decide which of these would most benefit particular police needs. As there are bound to be a number of unknown factors in a study of this magnitude and importance, the decision has been taken to break the work into separate stages which, in turn, can be sub-divided into phases, making it easier to change the emphasis and direction of the work should it become necessary to do so.

A contract for stage 1 of the MADE project was placed with the Marconi Company on 15 February 1971. The first phase of the work concerns a study by the contractor to determine the basic technical parameters of the system, followed by a report. Meanwhile the study group as a whole is deciding (in considerable detail) just what facilities ought to be tried in the experiment proper. Work on the second phase will involve the production of a small number of prototype models and their installation in police vehicles, followed by a technical evaluation. If this second phase of stage 1 meets requirements and expectations, the contractor will go ahead with the third and last phase of stage 1, that of the overall specification of an Experimental Automatic Data System for use in stage 2 (the experiment proper), which will involve a full-scale technical and operational evaluation of the system with the five forces. It is estimated that stage 1 of the MADE project will be completed in late 1972 and that stage 2 is likely to take two years to complete.

The MADE project has wide-ranging possibilities and is likely to have a profound effect on police communications in general. It cannot be considered in isolation from others aspects of police communications nor from possible developments on police command and control needs, and for this reason MADE is planned to interface with the present Birmingham Command and Control Experiment, and to take account of the introduction into service of the Police National Computer.

J N Hallett

J N Hallett who joined the Directorate in July 1971 is Project Officer for the Mobile Automatic Data Experiment. Prior to his appointment in the Home Office, Mr Hallett held the rank of Colonel in the Royal Corps of Signals and was on attachment to the Ministry of Defence.

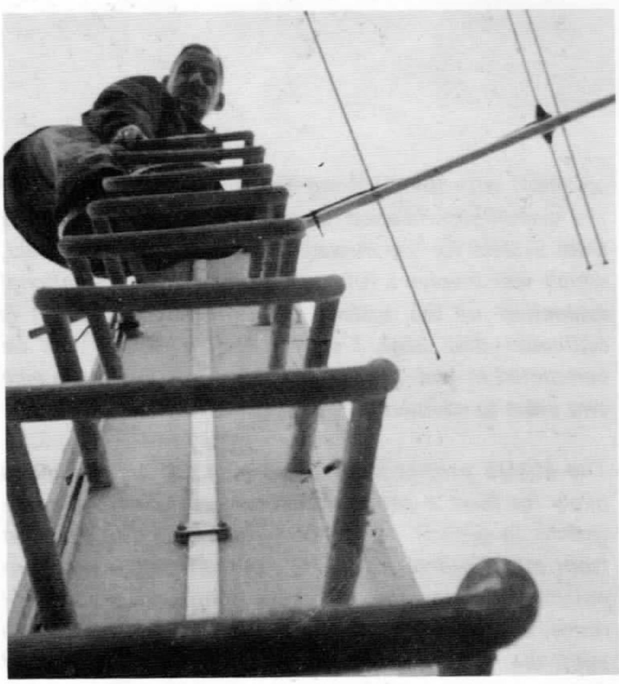
A MAST

THE AESTHETICS OF ENGINEERING

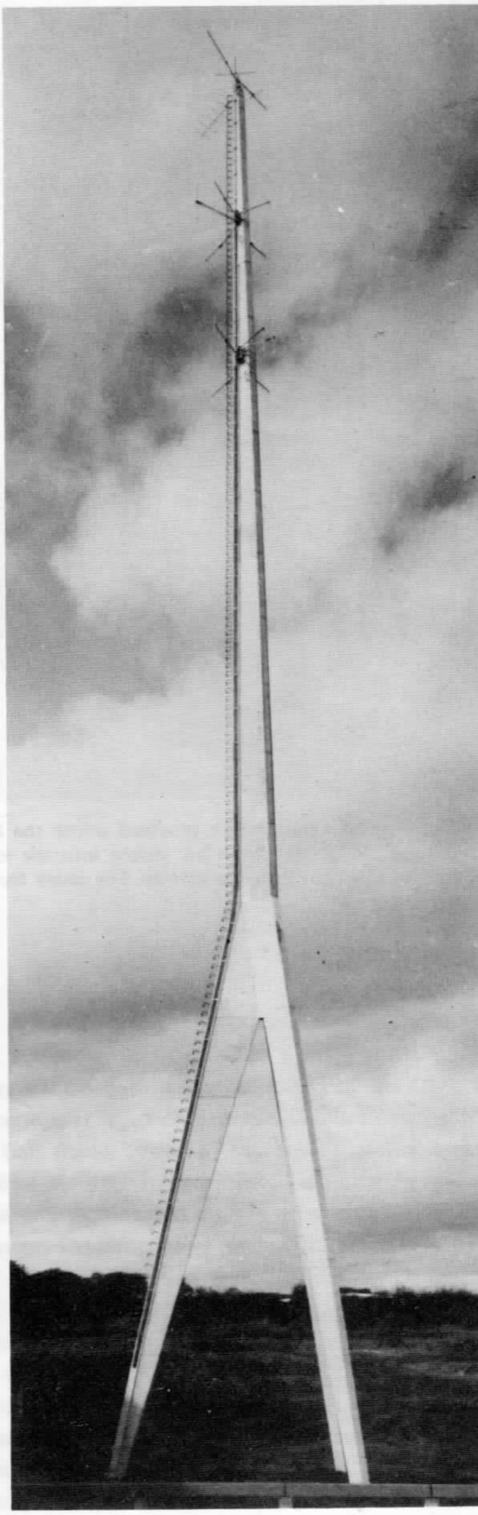
With environmental pollution all the rage (and quite rightly so) and with the subject covering a number of hate-objects ranging from nuclear waste, through unneeded plastics, scattered bottles and paper bags to a neighbour's taste in non-music, it is an excellent thing to be reminded that utility need not mean ugliness and that good engineering is capable of creating designs of great beauty.

With the construction of the new police headquarters at Aykley Heads, Durham, there was call for an aerial mast of at least 150 feet in height to carry the directional aerials of the radio system. With scarcely a thought—or so one would imagine—engineers envisaged a good old standard steel lattice tower of the kind which has always served us so well. This could be erected in the normal manner and with the minimum of fuss. It would stand for perhaps two generations and might even acquire with the passage of time a reputation for beauty in much the same way that certain Victorian monstrosities have in our own age.

In this instance, it would appear that the engineers had overlooked the presence of Durham Cathedral, an accomplishment that deserves surely a doffed hat at least. The Cathedral, standing not one mile from police headquarters, it seems, has also its claims on the minds of men. Understandably, the local Planning Authorities had little relish for the good old lattice tower so close to the jewel of the county palatinate.



Sam Young (Senior Wireless Technician) high on the Durham mast.



At this point, architectural design was applied to practical need and the visual aspect of the problem was solved by the construction of a reinforced concrete mast by Bierrum and Partners to a design of Ove Arup and Partners. The result visually was a landmark of clear-cut and simple beauty that detracts not at all from the historic presence of the cathedral and may even be considered by some to enhance the time-honoured lines of the older construction with its stark simplicity.

The mast stands 162 feet high, rearing a single finger of conrete to the sky and based strongly on a tripod of legs

60 feet long. Preliminary structural analysis was carried out on a computer. This, in conjunction with other studies, convinced the designers that such a structure would be stable in winds up to 90 mph. Because of the damping characteristics and high natural frequency, energy imparted to the mast was low.

As there was some speculation among men who knew about such things concerning the safety of men who climb masts for a living and as the sight of this new structure is awe-inspiring to one who grows giddy ascending the top-deck of a London bus, we approached two experienced aerial riggers.

In the corridors of the Central Communications Establishment at Harrow, we ran into Mr S Young, Senior Wireless Technician, and Mr C Sinclair, Aerial Rigger. Legend has it that Sam Young has assailed at one time or another every kind of structure made by man that thrusts towards the clouds and still climbs 1,000 feet of lattice with the same verve he exhibited 20 years ago. Both Sam Young and Charles Sinclair said that, though they found the Durham structure strange at their first attempt on it and the U-treads were somewhat unnerving when a safety-belt swung a rigger around one of its bends, a climber quickly becomes accustomed to it. Once it has been tackled, it is no more difficult than any other kind of mast.

The Durham mast may or may not be, as the in-words have it, economically viable or even cost-effective, but at least it means that for once the technologists cannot be blamed for an environmental atrocity. A thing of beauty, after all, is a joy, if not for ever, for a long time.

FIRE SERVICE COMMUNICATIONS

An Introduction

J Brock

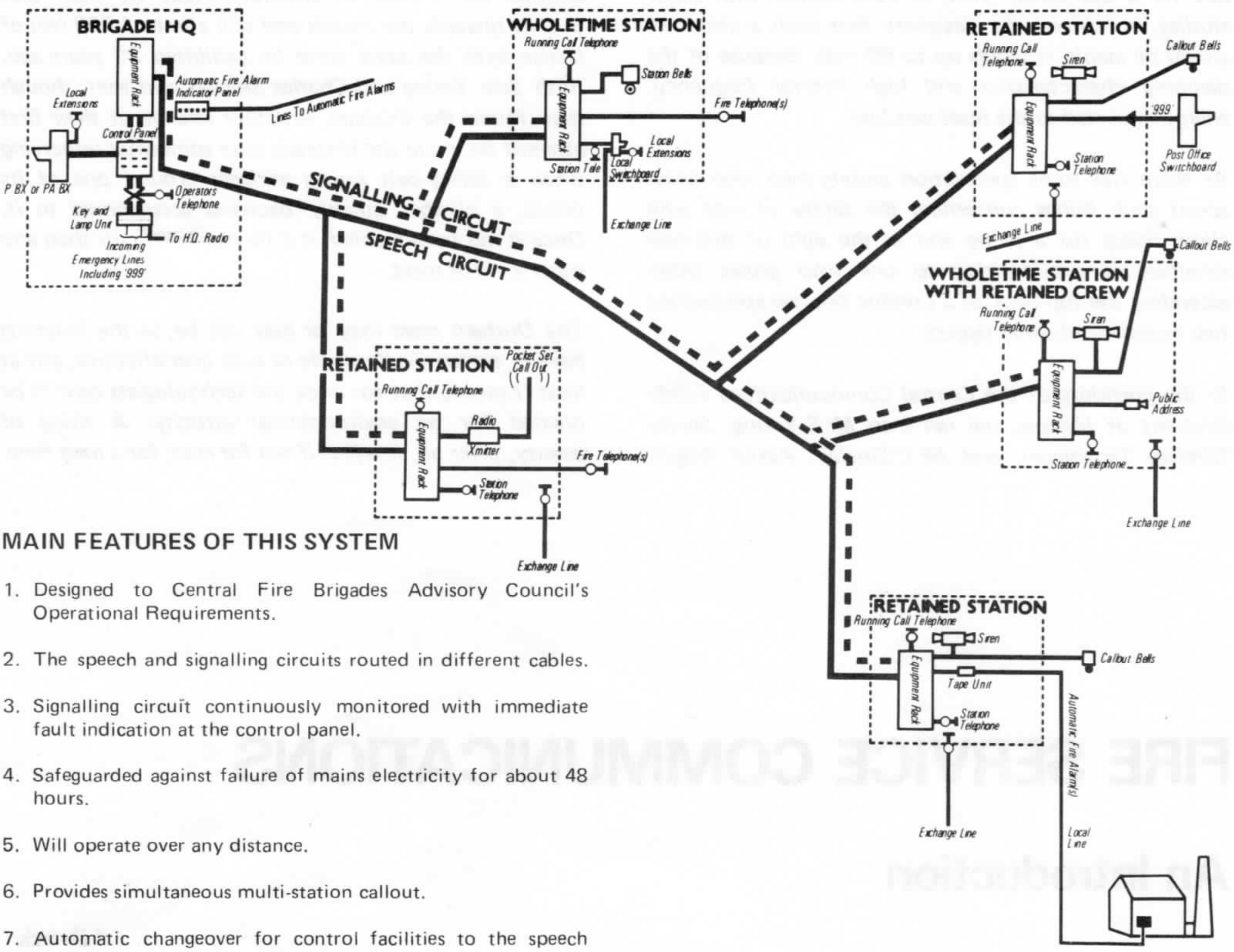
This article is aimed not at those who are intimately concerned with Fire Service communications, but at those readers who are either involved in isolated facets of the subject or who have a general interest in it.

When an emergency occurs—be it fire or one of the many accident emergencies which occur—our first thought in this country normally is to dial 999, after which one should ask for the emergency service required, eg Police, Fire, or Ambulance Service.

It is what happens after that which leads us to the subject of different types of communications systems and facilities required by each of the emergency services. It is not infrequently assumed, quite erroneously, that the same set of communications facilities could equally well serve Police, Fire, and Ambulance Services. In fact, the operational requirements for communications systems for these three Services vary a great deal.

It should be realised that the Fire Service is the only emergency service in this country which is equipped with the tools and special apparatus not only for fighting fires, but also for dealing with a whole range of special Service incidents, varying from rescuing trapped animals

VOICE FREQUENCY REMOTE CONTROL SYSTEM FOR THE FIRE SERVICE



MAIN FEATURES OF THIS SYSTEM

1. Designed to Central Fire Brigades Advisory Council's Operational Requirements.
2. The speech and signalling circuits routed in different cables.
3. Signalling circuit continuously monitored with immediate fault indication at the control panel.
4. Safeguarded against failure of mains electricity for about 48 hours.
5. Will operate over any distance.
6. Provides simultaneous multi-station callout.
7. Automatic changeover for control facilities to the speech circuit in the event of line failures.
8. Any number of automatic fire alarms and fire telephones can be connected at remote stations.
9. Speech circuit available for brigade administration calls with over-riding priority for fire calls.

to extricating badly trapped casualties in road and other accidents. Its basic and primary operational communications requirements are as follows.

Firstly, there must be adequate and efficient arrangements for receiving emergency calls from the public, as well as from automatic fire alarm systems. Secondly, there must be efficient facilities for quickly alerting the fire appliances nearest to the incident so that wheels are turning, in the case of whole-time stations, in not more than one minute from receipt of the call. This fast handling time can only be achieved by use of efficiently planned control rooms served by extremely fast and highly reliable communications systems. 'Seconds count' is certainly not an exaggeration when describing Fire Service organisational requirements, for the obvious reason that the saving of seconds can, and often does, result in the saving of lives and property.

Since about 1960, there has been a rapid increase of what in the Service are known as 'centralised mobilising schemes' in which all emergency calls for the Fire Service from within fairly large areas are all routed to and received at one central control room, instead of being handled locally at individual fire stations. It is now commonplace for there to be only one centre in areas such as a large county or city.

There are two prime reasons why centralisation of mobilising and communications in the Fire Service has become the common trend and the first of these is the fact that the ever-increasing cost of manning a large number of fire-station watchrooms for the local receipt of emergency calls has made that practice uneconomical. The second is that automation of the public telephone system which involves a steady reduction in the number of operator-manned telephone exchanges, makes it more efficient purely from a communications point of view. Furthermore, a well-equipped centralised control room staffed with specialist operators is more efficient than a station watchroom manned by operational firemen on a rota basis.

Unlike the Police, whose resources are normally mobile for most of the time, Fire Service applicances are normally standing by at fire stations ready for instant *turn-out. Wholetime firemen are alerted on fire stations either by alarm bells or by public address systems, coupled with emergency turn-out lighting, automatically opening doors, etc, while men on stand-by for fire duties whilst at home, work, or local recreation, are alerted either by a combination of fire sirens and call bells at their homes or, more recently, by pocket radio alerting receivers—a system recently designed and produced for this rather special purpose by the Directorate of Telecommunications in collaboration with the Fire Department of the Home Office, the Fire Service Inspectorate, and the Central Fire Brigades' Advisory Council Joint Committee on Fire Brigade Communications.*

In the centralised mobilising schemes, these local alerting systems have to be remotely operated by speedy and reliable remote control facilities which at the present are, without exception, Post Office line remote control systems, the majority of which are designed specifically for this purpose. Where pocket radio alerting systems are in use, the line remote control systems operate a radio transmitter in the local fire station which triggers off alerter receivers carried by the firemen. Whether such line systems will ever be replaced by radio facilities remains to be seen but, at present, there is no doubt that the backbone of the Fire Service communications (the system and facilities which are used to despatch appliances and equipment to fires and other incidents) is these line remote control systems.

It is not until appliances and officers become mobile that the radio facilities with which all fire brigades are equipped come into their own and provide the essential communications between mobile units and their respective controls, as well as with each other. These radio facilities also serve as an invaluable stand-by for mobilising purposes in the event of failure of line systems. In other words, Fire Service operational communications today consist of very comprehensive and highly safeguarded line remote control systems backed up by mobile radio schemes and, in view of the vital nature of the emergency service provided, the general view held in Fire Service circles is that since centralised mobilising appears to be here to stay, the need for comprehensive line and radio systems is likely to be regarded as essential for some years to come.

With regard to the types of line systems used—four large fire brigades (London, Surrey, Hampshire, and Cheshire) use teleprinter networks for remotely controlling alerting systems and for passing turn-out instructions, systems which have been in use from about 1959. Since that date, practically all fire brigades which have adopted centralised mobilising have used a new remote control system designed specifically for this purpose called 'VF System A', a system which was produced by the Post Office to meet detailed operational requirements prepared by the Home Office in collaboration with the Joint Communications Committee of the Central Fire Brigades' Advisory Council. There are still a few old remote control systems in use in some areas (including System DX which relies upon connections made over the public telephone network; System K which is a monitored point-to-point private wire system; and some non-standard private wire systems with 'fire-flash' facilities which are used to trigger remote alarm systems), but in the majority of cases these are in the process of being replaced by 'VF System A'.

Diagram 1 gives a schematic layout of one group of VF System A which, as can be seen, serves a group of five fire stations. For technical reasons, this is the maximum number of stations which can be served by any one group. Each group is served by what is in effect a double private wire network with spurs out to the fire stations, these private wires being alternatively routed so far as is practicable. One line is normally used for carrying all the signalling facilities which will operate the system and the other line is normally used for speech. The signalling circuit is continuously monitored to give immediate warning of faults as and when they occur. Facilities are provided to enable the signalling facilities to be switched on to the speech circuit when necessary, thus giving an immediate alternative and enabling stations still to be alerted in the event of signalling line failure.

As the diagram shows, the system can also be used as a collecting system for incoming emergency calls from 'running call telephones', provided at fire stations for use by the public in the event of the station being unattended; and for calls from automatic fire alarm systems and fire telephone circuits, a facility which is offered as an encouragement to the owners of premises protected by automatic detector systems to have a reliable and continuously monitored connection to the fire brigade. Whilst no attempt is made in this article to give a detailed description of this system, it is sufficient to say here that VF System A has proved itself for several years under operational conditions and is generally regarded in the Service as highly satisfactory.

So far as radio facilities for the Fire Service are concerned there is at present a good deal of demand within the service for improved systems and facilities and the reasons for this are briefly as follows.

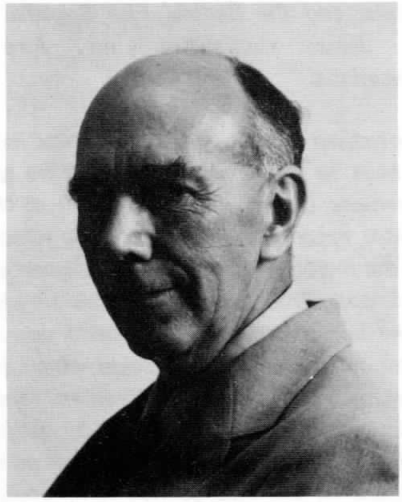
Until about 1963, all but about six of the bigger fire brigades shared radio facilities with the Police and, because of the confliction between Fire and Police traffic requirements fire brigades did not make maximum use of radio. However, from about 1964, it was possible for fire brigades to be provided with exclusive radio schemes. At that time fire brigades were provided with what amounted to virtual replicas of the Police radio schemes. It was not until brigades began to appreciate the advantages of having full control of a radio scheme that they began increasingly to use radio, and then all concerned began to realise that the standards of cover provided by the schemes and the *general quality of signals provided by them did not always match up to modern fire brigade requirements.*

As a result, there is now a great deal of activity within fire brigades and the Directorate of Telecommunications aimed at providing schemes giving better cover and in general better quality performance than existing schemes. Improved coverage is necessary primarily because, when a fire appliance draws up at a fire and connects its pump to a hydrant or other water supply, it becomes virtually immobilised in that spot until the incident has been dealt with and, if that spot happens to be in an area of poor coverage, the crew is bereft of radio communication.

The need for noise-free and very clearly readable signals is particularly important, because fire appliances, which are practically all equipped with radio, are rather noisy beasts. The powerful engines which drive not only the vehicle when mobile, but also the pump when at an incident, produce cab noise which can be extremely high. This situation creates obvious difficulties, especially if radio reception is weak or signals are hard to read due to poor signal to noise ratio. It is hoped that in the near future, the efforts of the Directorate of Telecommunications will be successful and that schemes will be produced which not only give improved coverage and a higher grade of performance but which will also permit the provision of such additional facilities as selective calling for officer-paging purposes, interfaces with personal radio sets, etc to be added when and where required.

There is a growing demand in the Fire Service for personal radio facilities both for paging purposes and for use on the fireground, so that better use can be made of officers and firemen on a wide range of duties away from their fire stations, whilst remaining on immediate call for fire duties. Similarly, it is hoped that the research, which is at present going on into the provision of improved personal radio facilities for fireground use will be successful, because in this particular field the systems at present in use fall short of providing satisfactory communications in the wide variety of circumstances encountered on fires and other special services. Some of these requirements pose quite difficult communications problems for the technical people responsible.

Coupled with the general need for improved fireground communications is the rather special need of firemen for communications when using breathing apparatus. In this situation whatever communication system is used must be of an exceptionally high standard of reliability. Failure of a communication system in the dangerous circumstances that necessitate the use of such apparatus may easily endanger a fireman's life.



John Leonard Brock saw operational service from the start of the Second World War until 1948 in the Fire Service. Area Communications Officer No 30 Fire Force. Until 1952 he was Brigade Communications Officer to Kent Fire, then became Assistant Inspector of FS Communications and is now Fire Liaison Officer to the Home Office Directorate of Telecommunications.

While no attempt has been made in this article to deal in detail with the many different aspects of Fire Service communications systems and facilities, it will have achieved its aim if it has done something to impress the reader firstly that good initial response and subsequent operations are dependent upon efficient communications; and, secondly, that the effects of centralisation and the growing importance of making even better use of available manpower creates an urgent need for new communications facilities, additional to the basic line and radio systems.

MOBILE COMMUNICATIONS

John Titheradge

John P Titherage, CEng, MIERE, Chief Wireless Engineer in the Directorate, served with REME during the Second World War and joined the Home Office as Chief Wireless Technician. Later promoted to Wireless Engineer, he worked in the Ministry of Civil Aviation from 1953-70, before returning to the Home Office in his present post dealing with fire and civil defence telecommunications.

This article deals with nothing that is either startling or new. It is aimed at those of our customers who make use of radio communications, and if it arouses critical thought and constructive ideas on ways in which their particular requirements can be improved, then it will have attained something of its purpose.

The use of radio for mobile speech communications systems has been seriously exploited for more than 40 years in this country. Some readers will recall the early medium frequency installations upon which the siting of the Home Office Regional Wireless Stations was based, those original stations (Fig. 1) now performing the functions of Regional Maintenance Depots. Medium frequencies were, in fact, used far more for mobile communications than is generally realised, particularly in the United States, and for air/ground systems throughout the world. However, there were many adverse factors associated with the use of these frequencies for ground mobile purposes—in the equipment performance, aerial requirements, and propagation characteristics. Most people will have noticed what happens to broadcast reception on their domestic receivers or car radios when they are tuned to the medium waveband, particularly during the late hours when considerable variations in range and quality occur, giving rise to foreign interference, selective fading, and other unpleasant effects which result mainly from the nature of the propagation path followed by the waves and the manner in which the ionosphere affects them.

As the frequency of transmission is raised or the wavelength becomes shorter, which is the same thing, a point is reached at which the transmission or propagation is mainly determined by the visual range from the transmitter or follows line of sight. This is the VHF region of electro-magnetic waves (Fig. 2). In the shadow of hills, reception falls off and is limited fairly rigidly by the curvature of the earth in all directions (Fig. 3). However, even with a very low power transmitter and, say, a 100-foot aerial mast, a typical working range over flat country is some 15 to 20 miles, given equipment of adequate sensitivity (Fig. 4). Extreme conditions in the earth's atmosphere can cause these waves to depart occasionally in their behaviour from the mean and, now and again, under freak conditions, long-range interference occurs, such as we all experience with television reception and most of our customer services with their VHF mobile radio schemes. At this point, we realise the plain truth that nothing can be done to alter the basic laws of propagation.

FREQUENCY SPECTRUM

For the sake of our lay readers, let us refresh our memories on the basic range of the spectrum and the uses to which it is put. Fig. 2 illustrates the whole spread of the spectrum from zero frequency, or DC as we know it electronically, through power supply and sound frequencies, to radio into the LF, MF, and SW frequency bands, and then to VHF TV and mobile radio, on to UHF TV and into radar systems and micro-wave links. Beyond this, we pass into the infra-red and the visible light regions in which, incidentally, laser beams find their applications, and then out of visible light into ultra-violet. We then get into the region of X-rays and finally into the gamma and cosmic ray regions which are of great interest to our radiac, nuclear, and space scientists. You will notice, however, the relatively small portion of the total spectrum available for communications using techniques as we know them today.

DEVELOPMENT OF VHF

With the rapid development in the art of radio, the advantages of VHF, particularly in relation to the design of equipment and system performance, soon became apparent and, in this country at least, VHF superseded medium frequencies for ground mobile communications, with minor battles being waged over the relative merits of amplitude and frequency modulation as side issues.

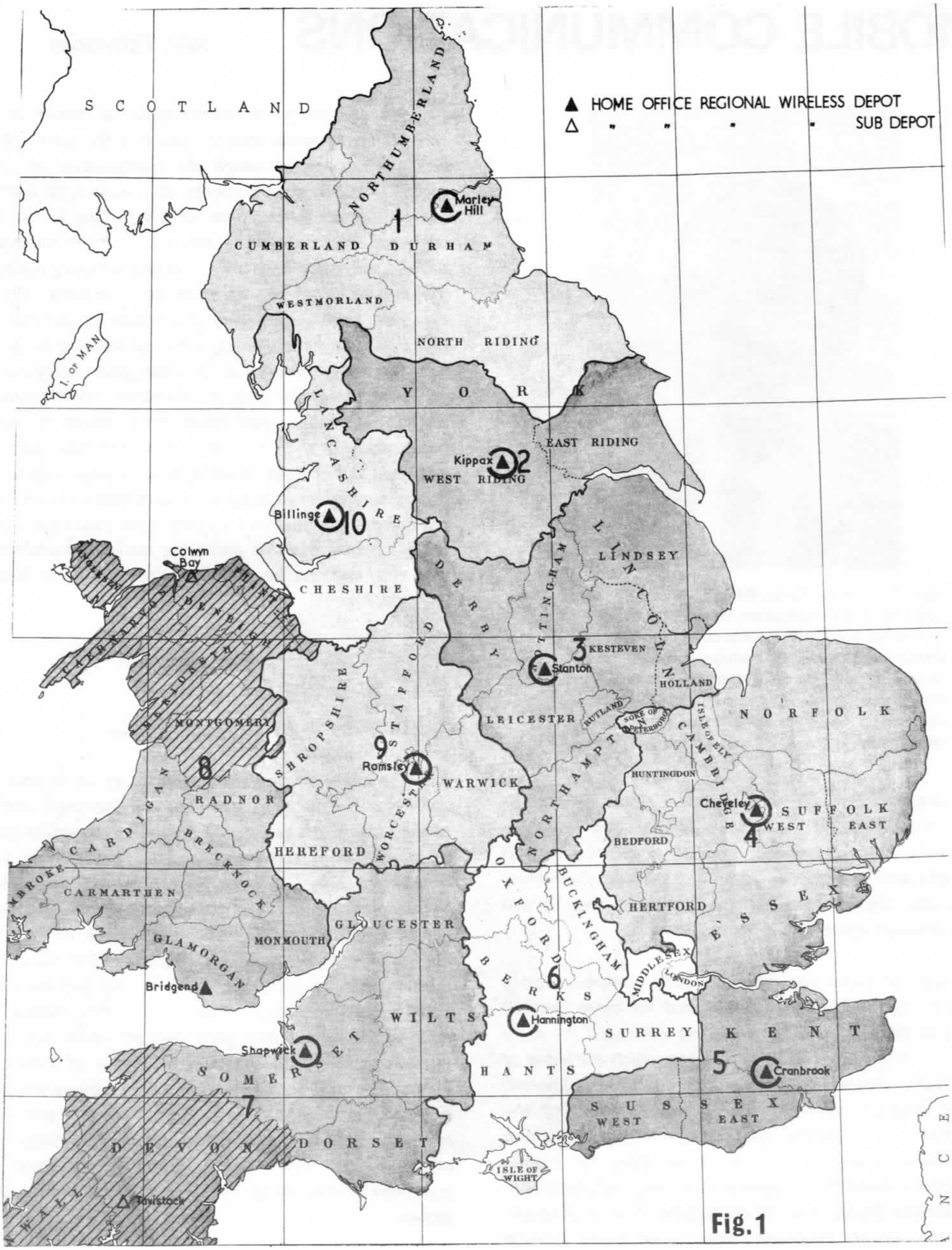


Fig.1

The aviation world settled by international agreement on VHF for the bulk of its air traffic control communications and thus, for some years, both during and after the last war, tremendous impetus was given to the development of VHF equipment and systems. During this period, the Home Office embarked upon its major development and installation programme for police and fire services, and by 1952 substantial areas of the UK were equipped with mobile radio schemes.

AMPLITUDE AND FREQUENCY MODULATION

The basic link between the transmitter and the receiver is a carrier wave generated in the transmitter, upon which are impressed variations conforming with the speech or intelligence to be conveyed. The carrier wave may be varied either in amplitude or in frequency in sympathy with the speech signal (Fig. 5) and, at the receiver, these variations are converted into currents which activate the loudspeaker or headphones. The carrier wave may be varied in several other ways to convey the same intelligence, but I will not attempt to describe these now for fear of confusion, except to add that the expression frequency modulation is often loosely used to include phase modulation which behaves in a similar manner.

With regard to the general nature of AM and FM, however, there are several fundamental differences which positively determine the choice of one or the other for specific applications, but these are generally outside the field of pure mobile communications and are of real importance mainly to such systems as hi-fi broadcasting, multi-channel telephony, telemetry links, and so on, for which FM is appropriate. However, we are concerned with the basic mobile radio telephone application and, although in the early days it was accepted that FM required a wide bandwidth to realise its full benefit, at that time, even for mobile applications, channel bandwidths were ample and the improvement from FM could be fully realised.

readily be applied to FM systems for a number of reasons, although attempts were made with a moderate degree of success, notably by the Lancashire and Ayrshire police forces. Nevertheless, the AM multi-carrier system was also accompanied by some adverse effects observable mainly as a degradation of quality in regions of roughly equi-signal strength. There was also the possibility of whistles or beats arising, the elimination of which dictated the need to limit the number of stations in a scheme to three at most, unless exceptional geographical conditions permitted a fourth station. The system called for a high, but not exceptional, degree of stability in the transmitter frequency control. However, the relative simplicity of the system engineering, and the advantages of the large area cover, were deemed to outweigh the disadvantages. This ability to cover simultaneously a large area was a fundamental operational requirement of police and fire service schemes based mainly on county areas as they were and, of course, to airways systems for the flight information regions. Hence, for these reasons, AM multi-carrier systems were given the full go-ahead.

FREQUENCY SPECTRUM

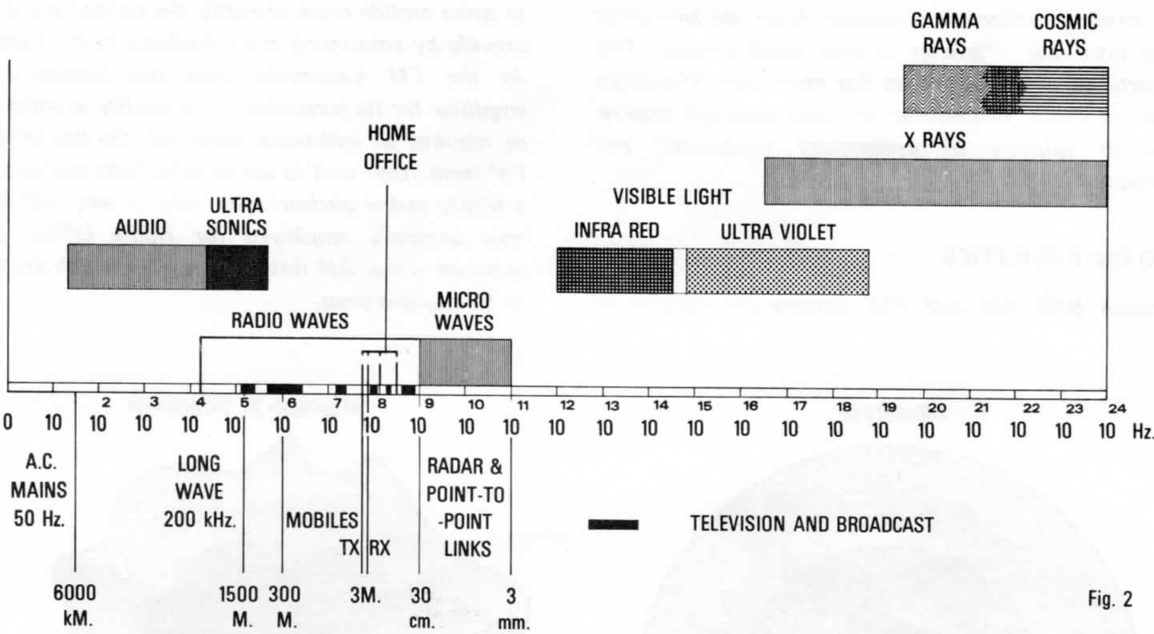


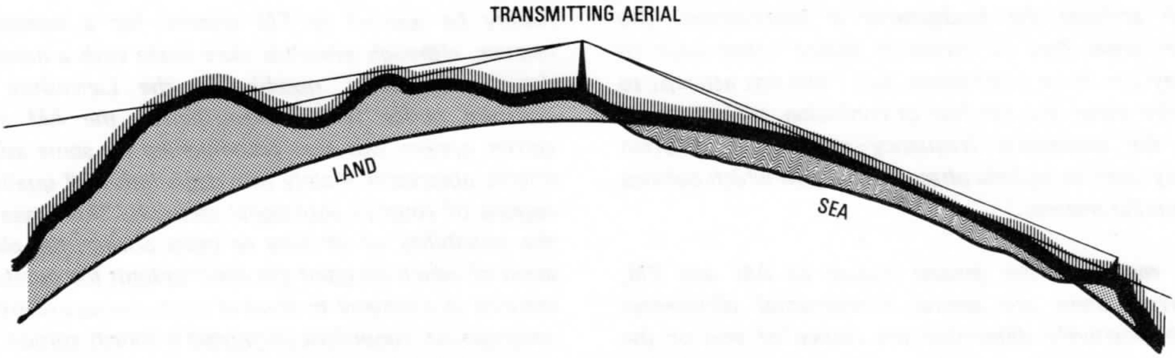
Fig. 2

EARLY CHOICE OF AM

Despite this, however, there was one major reason which influenced the Home Office choice (and that of civil aviation) to use amplitude modulation. This was the ability to apply to AM systems the principle of multi-carrier operation which permitted a number of transmitters to radiate simultaneously, bearing the same speech intelligence, and thus to cover a very large area not limited to the line of sight path from one transmitter alone (Figs. 6, 7, 8). This principle could not then

AM AND FM CHARACTERISTICS

There are some differences in the characteristics of AM and FM of which one must take note. The FM receiver has a pronounced squelch action and 'capture' effect, whereas AM generally has a less abrupt or softer muting action and is usually accompanied by a falling off in volume level as the signal approaches the threshold value. With the present-day reduction in channel bandwidth, the difference in threshold performance of AM and FM receivers has become less marked—noise



EFFECT OF TOPOGRAPHY AND EARTH'S CURVATURE

Fig. 3

becoming a problem with both systems, but my own opinion, backed by some experience and by manufacturers' performance figures, is that FM has the edge on AM and that the extended threshold performance gives a worthwhile improvement in range. But perhaps the most important property of the FM receiver which distinguishes it so markedly from its AM counterpart, is its ability to 'capture' the strongest signal when two or more signals are applied to the input simultaneously. For this to occur, the relative strength of the signals need only differ by a small amount. On the other hand, the AM receiver suffers interference from an unwanted signal until the difference is very much greater. This property of the FM receiver has important advantages when we come to consider the area coverage requirement in relation to present-day equipment and techniques.

'ADD ON' FACILITIES

Although both AM and FM systems are capable of having selective calling, paging, vehicle location, and remote control systems applied to them, these are easier to apply to FM, and more reliable in their performance, than on AM systems. The modulating tones used for such systems are applied in just the same way as speech, but are filtered out at the receiver to actuate buzzers, lamps, bells, sirens, or to perform any other function by means of simple relays. There are various other pros and cons in relation to AM and FM. For example, the public address facility usually embodied in the mobile AM transmitter has been proved to be of considerable value to some mobile users (notably the police) and is easy to provide by employing the modulator in the transmitter. As the FM transmitter does not possess a power amplifier for its modulator, this facility is either lacking or requires an additional amplifier. On the other hand, FM lends itself well to use in radio links and can provide a highly stable performance. This is why FM links are now generally employed for Home Office systems, although a few AM links still remain which are planned to be changed soon.

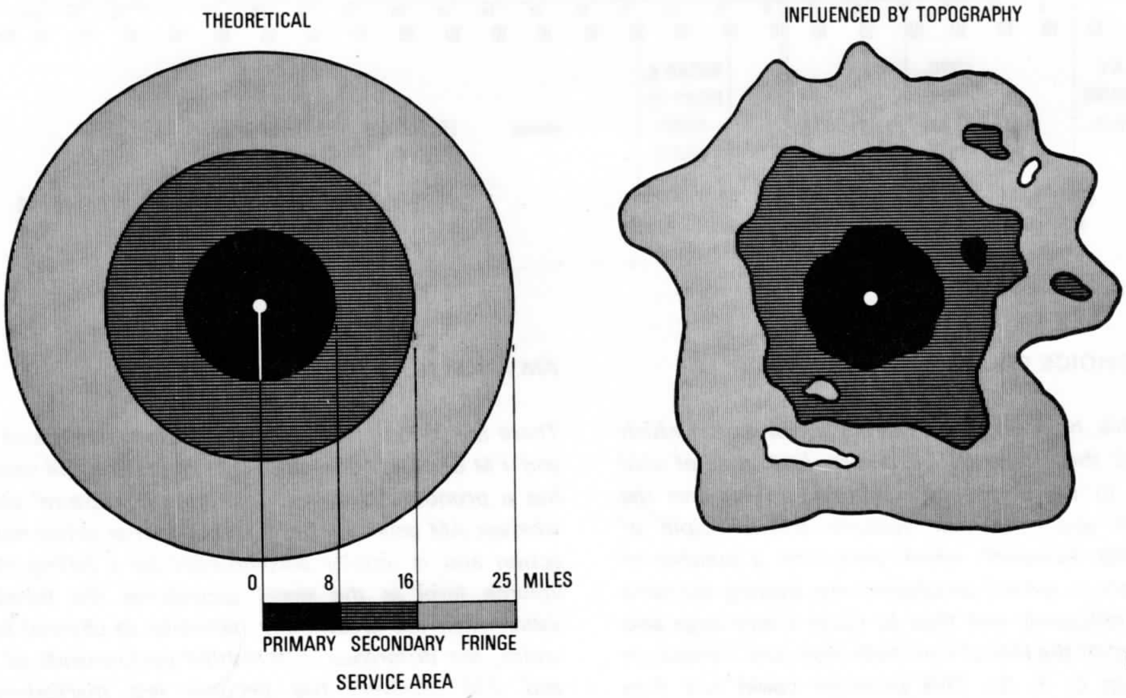


Fig. 4

ONE HUNDRED THOUSAND MOBILES— EXTENSION INTO UHF

As the congestion of the VHF frequency bands became acute, with the ever-expanding use of mobile radio for a wide variety of services (the number of mobiles operating in the UK now is of the order of 100,000), the need to extend into the higher frequency bands became apparent and, with the development of suitable UHF equipment, the ability to extend into this region on a large scale was fully exploited by the mobile-radio industry. It was found that the propagation of UHF frequencies followed line of sight even more closely than VHF, but possessed slight differences and generally gave better penetration of built-up areas and a better performance when operating portable sets from within vehicles—as, for instance, in the use of the police personal radio. The range in the open was generally found to be slightly inferior to VHF, but UHF lent itself very well to compact schemes which had fairly well defined boundaries, such as in the coverage of a city or a large town. The suitability of UHF for portable and personal radio equipment was quickly realised and fully exploited. Its use for fixed radio links, as mentioned above, in conjunction with frequency modulation was fully utilised. In the UHF bands frequency modulation finds almost universal application.

One great property of UHF which is of considerable advantage to the user of mobile radio is its relatively greater freedom from the effect of man-made noise, electrical interference, and vehicle ignition interference. The reader will have only to switch to the UHF channel on his television set, especially if he lives near a busy vehicle route, to notice the improvement.

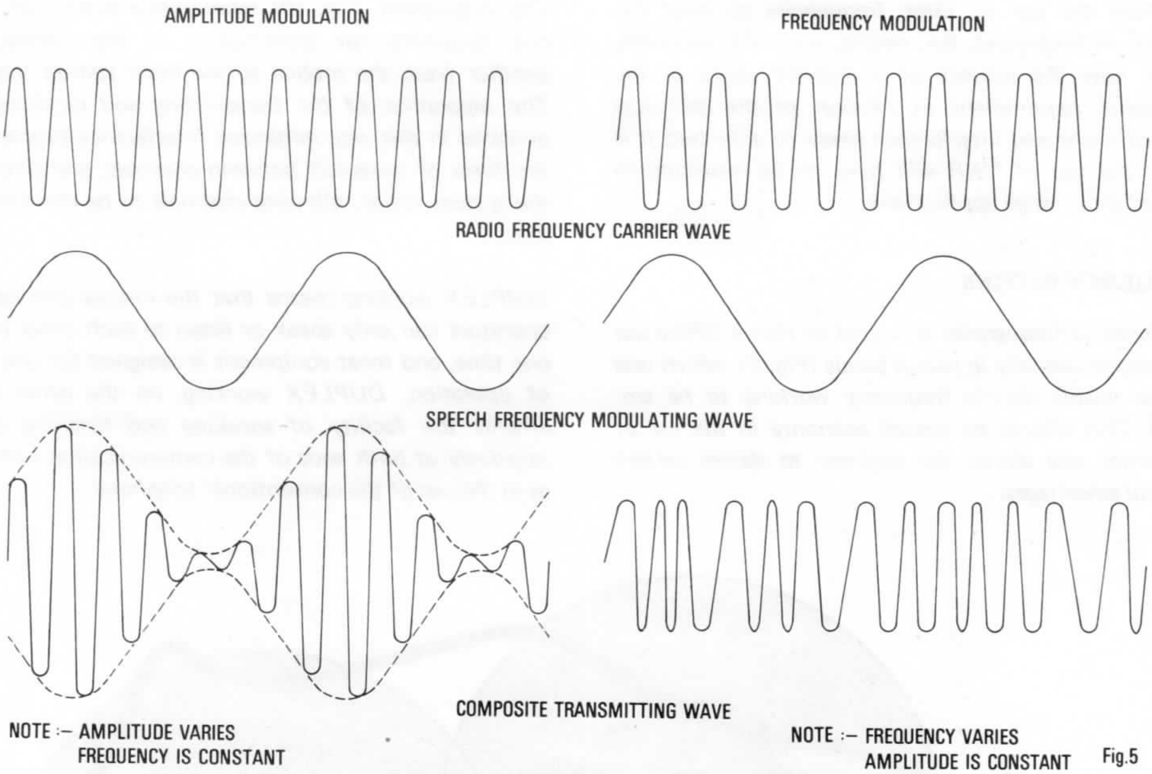


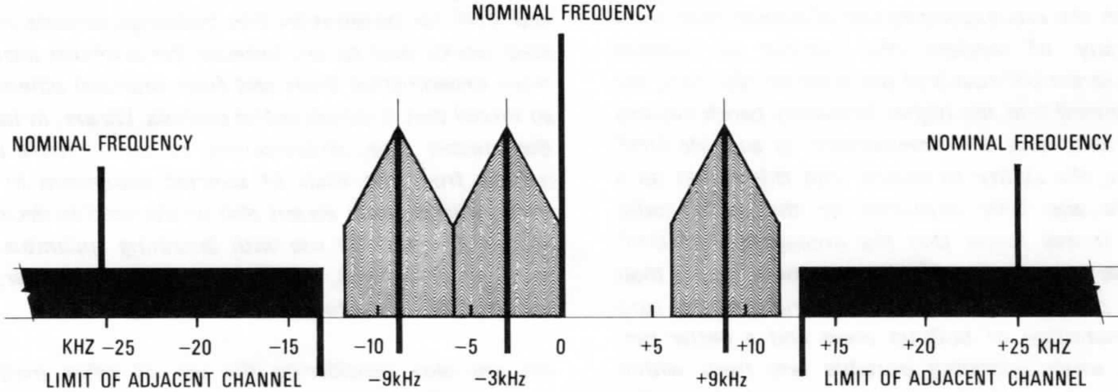
Fig.5

Returning to the subject of penetration, one dare not risk being too specific about the relative merits of UHF and VHF for penetration into buildings, tunnels, mines, steel works, and so on, because the evidence provided from experimental trials and from practical schemes, is so mixed that it almost defies analysis. We are, in fact, at the present time, endeavouring to obtain more information from the trials of selected equipment in such environments, with accent also on the need to decide on a suitable radio for use with breathing apparatus. For some environments, VHF appears to be better; for others, UHF seems to have the advantage.

We are also considering the use of other methods, including the use of very low frequency bands, and there is still plenty of scope for original work in this area. The choice of a particular system may well have to be determined by factors of cost, weight and compactness of equipment, the size of aerials and whether AM or FM and, of course, the question of equipment availability from commercial sources. Looking at the situation over all, it is plain that there is no simple solution at present available to the problem of providing solid two-way radio communications into any type of building, seaborne or underground structure, despite the impressions given by television scriptwriters. However, it will be interesting for all fire officers to know that despite the extreme shortage of UHF frequencies, arrangements have now been made to allocate two pairs in the pocketfone bands for Fire Brigade use on a countrywide basis. We have not decided, so far, exactly how to apply

ARRANGEMENT OF CARRIERS IN 3 STATION SCHEME

Fig.6



and share the use of these frequencies to meet the demands of fireground, BA, paging, and other purposes. This is now the subject of a detailed study of the operational requirement in relation to the technical issues of range and interference likely to arise but, it is feared, the use of UHF will have to be restricted to localised short range applications.

FREQUENCY BLOCKS

The blocks of frequencies allocated to Home Office use are arranged basically in paired bands (Fig. 9), which was done to enable double frequency working to be employed. This affords an overall economy in the use of frequencies and allows the engineer to derive certain technical advantages.

The illustration (Fig. 10) represents a system of using one frequency for transmission to the mobile, and another from the mobile to the main station receiver. The separation of the transmitting and receiving frequencies in this way minimises interference problems in the form of cross-talk between channels, and simplifies the system design, allowing channels to be more closely spaced.

SIMPLEX working means that the mobile and control operators can only speak or listen to each other at any one time, and most equipment is designed for this class of operation. DUPLEX working, on the other hand, affords the facility of speaking and listening simultaneously at both ends of the communication path just as in the use of the conventional telephone.

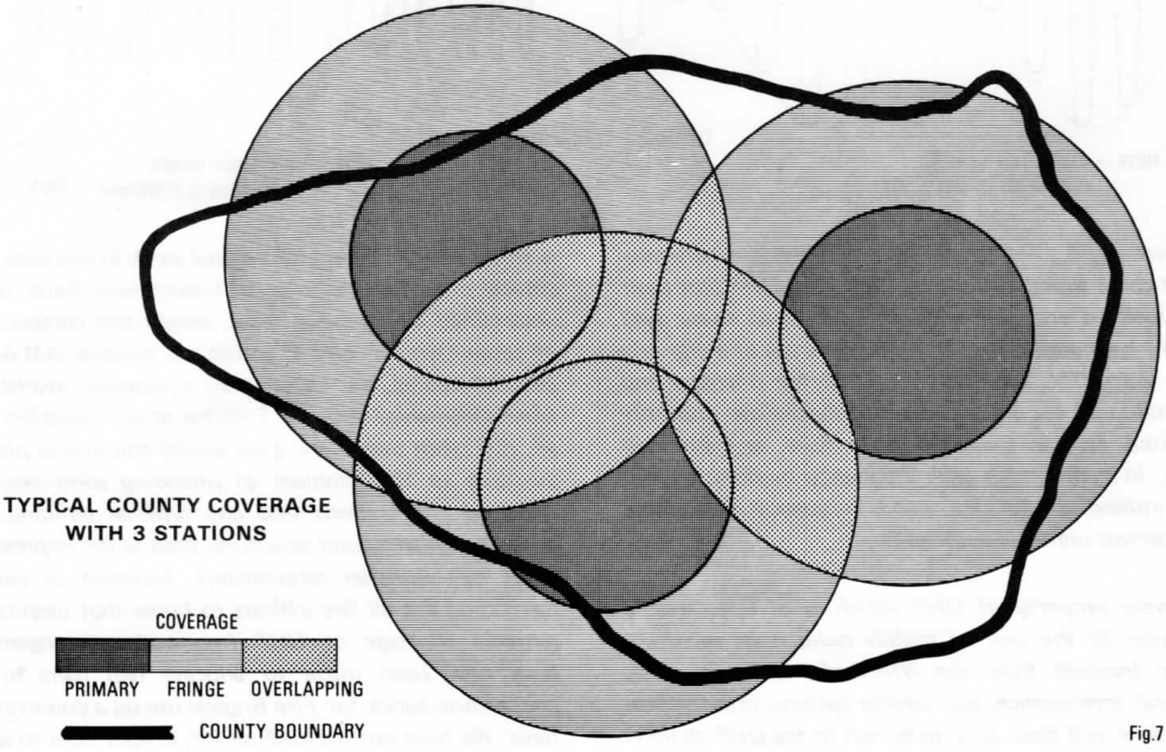


Fig.7

SINGLE FREQUENCY SYSTEMS (Fig. 11), employing the one radio frequency for both transmission and reception, can only be used on a simplex basis. For technical reasons, both single frequency and duplex systems are to be discouraged, and from the operational point of view, opinion generally also appears to be against the use of duplex. However, in both cases there are other factors to be taken into account. Simplex operation affords the means of setting up direct man-to-man communication without the need to work talk-through via a control station. This has obvious advantages in difficult fireground situations and it may be preferable to some customer services to use pack-sets in this manner. Again, duplex working has been employed in some areas with claimed success, especially when combined with the exceptional facility of extending the radio network into the telephone system.

TALK-THROUGH WORKING (Figs. 10, 14) simply implies establishing two-way working between mobiles or out-stations via a main station or network of main stations. This allows the advantage in range of the better-sited and high-powered main stations to be used by the mobiles to talk together and, of course, is made possible only by the use of double frequencies. Talk-through working may also allow a mobile on one channel to converse with a mobile on another channel, given the necessary switching facilities at control (Fig. 12). The use of talk-through, though, is inevitably accompanied by an impairment of quality due to the number of transmission paths or links that the signal has to traverse between the distant ends. Entire schemes are sometimes operated on talk-through continuously, either from choice or necessity, as in the case of a brigade working as sub-control off another. In some cases, cheaper schemes can be obtained by this method, if taken into account when the system is planned. But the pros and cons need to be very carefully considered.

MULTI-CHANNEL OPERATION

Multi-channel operation implies the ability to switch the equipment to a number of distinct user-channels. The use of double-frequency equipment involves the change, on switching, of both the transmitter and receiver frequencies. For technical reasons, it is much simplier and cheaper to design and produce equipment capable of switching to a number of very closely spaced channels within a frequency bandwidth of something less than 1 MHz, rather than to use the same number of channels spread throughout the entire width of the frequency blocks allocated to Home Office use. Equipment to perform this latter and ideal function has so far been available only at very high cost, especially when combined with the ability to switch to FM as well as to AM.

The AF 101 transmitter receiver (Fig. 16) is one such equipment in this field. However, the situation is now showing considerable signs of improvement and it is hoped that, in the not-too-distant future, there will be generally available, from a number of manufacturers, moderately priced mobiles to meet this challenge. One such equipment is at present undergoing large-scale trials with both the police and fire forces in this country. If these are as successful as expected, the position will be much easier when we come to consider the provision of inter-scheme working and monitoring, but I feel that there will always by a requirement for the simpler and cheaper type of mobile, particularly where space considerations are of major importance. Here it is worth noting that the same wideband facilities will be available from fixed station equipment and it is predictable that this will simplify many of the inter-force communications requirements both for normal peace-time and other purposes.

THE BASIC PROBLEM

Having dealt so far mainly with principles, I want to come to what is perhaps the main point of this article. The fact that the basic problems facing the mobile communication systems engineer have remained substantially unchanged for the past 40 years or more.

These problems stem from the ideal operational requirement which is bluntly stated as 'a need to provide two-way communication over any specified area, at all times, with absolute reliability, complete intelligibility, despite geographical, climatic, and environmental conditions, operators' dialect or sex, and with traffic densities from virtually nil to disaster proportions'. For many years, communications engineers have striven to achieve this ideal objective, but the truth is that we are almost as far from it now as we ever were—controlled as man is by practicality and economics. We can dream and even talk of satellite communications, two-way with men on the moon as a reality, complex computer processing networks, and super telephone, teleprinter, and message switching systems, but we are forced to acknowledge that radio is at present tied to the fundamental laws of propagation, available techniques, and engineering economics.

COMPROMISE

This business of area radio communications is in fact all a matter of 'compromise'. I want to stress the word 'compromise'—and certainly every salesman knows it well. The BBC finds it necessary to employ effective transmitter power of the order of half a million watts to cover an area not much bigger than a large county, yet to provide a service in shadow regions, must install small, low-power filler stations, to offset the basic loss of propagation. This illustrates the futility of employing sheer brute force power where line of sight propagation

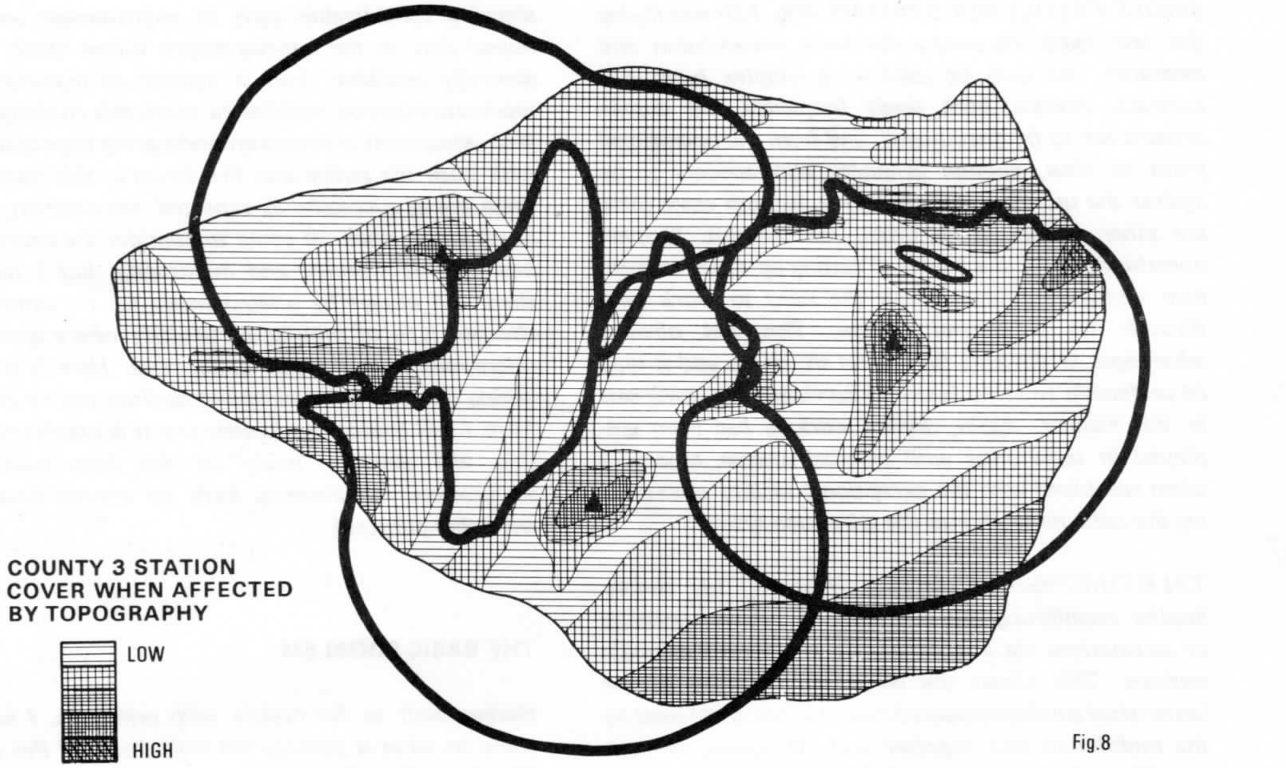


Fig.8

is concerned. Quite obviously, for technical and economic reasons, Home Office Telecommunications have to compromise, especially where mobile radio communications are concerned.

Radio interference, both from systems nearby and far away, presents itself to an ever-increasing extent, and is not easy to eliminate—especially when the sharing of technical sites is forced upon us and cost limits our ability to employ ideal methods of system engineering.

FREQUENCY ALLOCATIONS AND INTERFERENCE

The fierce competition throughout the country for the allocation of frequencies from the blocks available, forces us into ever-closer channel spacings, which in themselves give rise to extremely difficult engineering problems in the battle to exclude interference. The higher the power used, the more difficult the problem.

SEPARATE SITES

The subject of co-siting needs some amplification for it is well recognised throughout the communications engineering profession that the best chance of avoiding interference problems is afforded by the use of separate sites for transmitters and receivers. Ideally, they should

H. O. FREQUENCY ALLOCATIONS

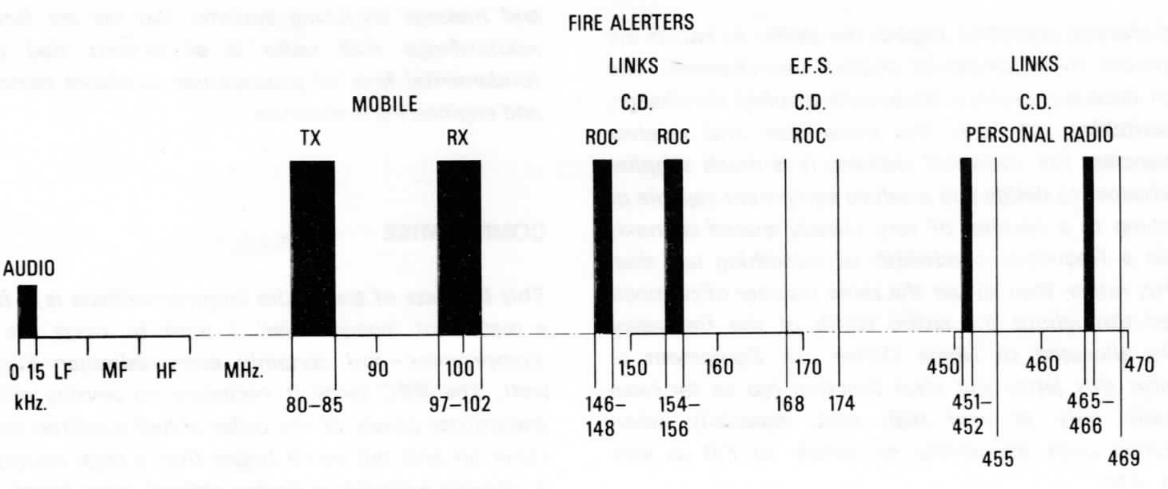
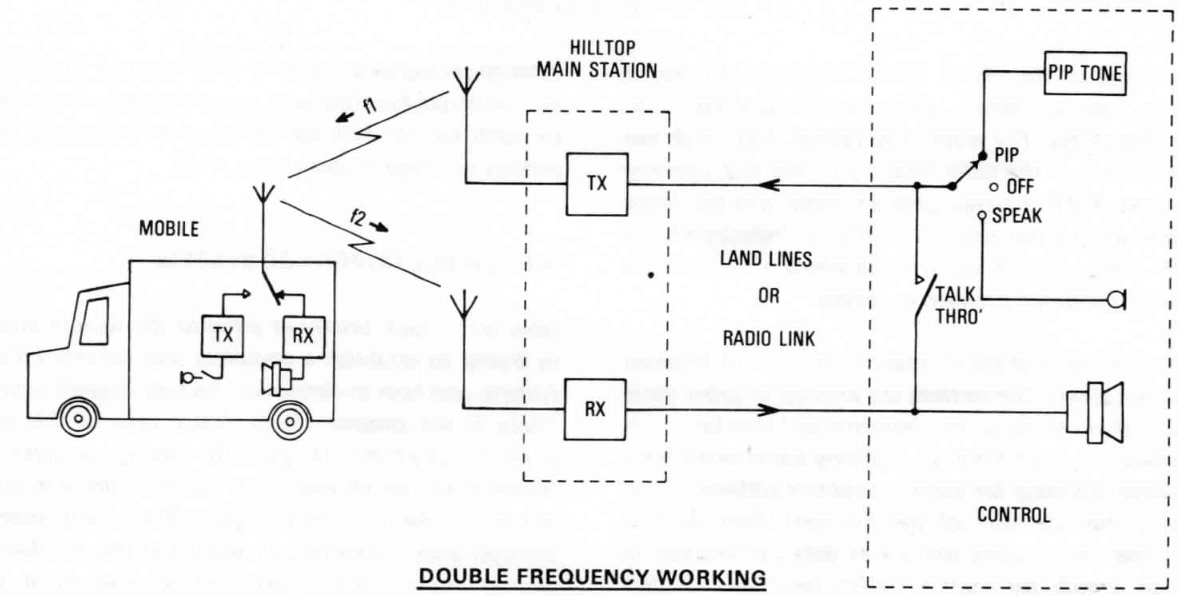


Fig. 9

be at least one mile apart. In aviation, and for long range commercial and government communications, this is accepted practice, but I am sure that all fire and police officers connected with communications are aware of our present difficulties and are equally aware that in the not-too-distant future, circumstances will force us to find a solution to this problem, a solution which, of necessity, will be to a great extent governed by cost.

PERFORMANCE

Equipment has changed in the last two decades, both in design and appearance, from valves to solid state, ebonite to plastics, and so on, but in performance, not so dramatically as one might suppose. The half-hundredweight or more of the 1946 mobile has been replaced by something weighing only a few pounds, which no one would deny is an improvement. The more modern equipment demands only a fraction of the power demanded from the vehicle battery by the 1946 equipment. Modern equipment is generally more reliable, but in basic performance, apparent to the user operator, there is in fact very little real improvement. Indeed, in some features the qualities of the present-day equipment are inferior to the old. Thus we find ourselves asking the inevitable question of what are the real benefits of technical progress. I often ask myself the same question when, for instance, I compare the postal, telephone, and public transport services with what they were 30 years or more ago—despite automation in sorting, two-tier systems, automatic signalling, diesel electrics, electronic exchanges, and the rest. The point is, of course, that society itself has become more complex and is raising communications problems of an appropriate complexity, the solving of which make financial demands which under some circumstances are unacceptable.



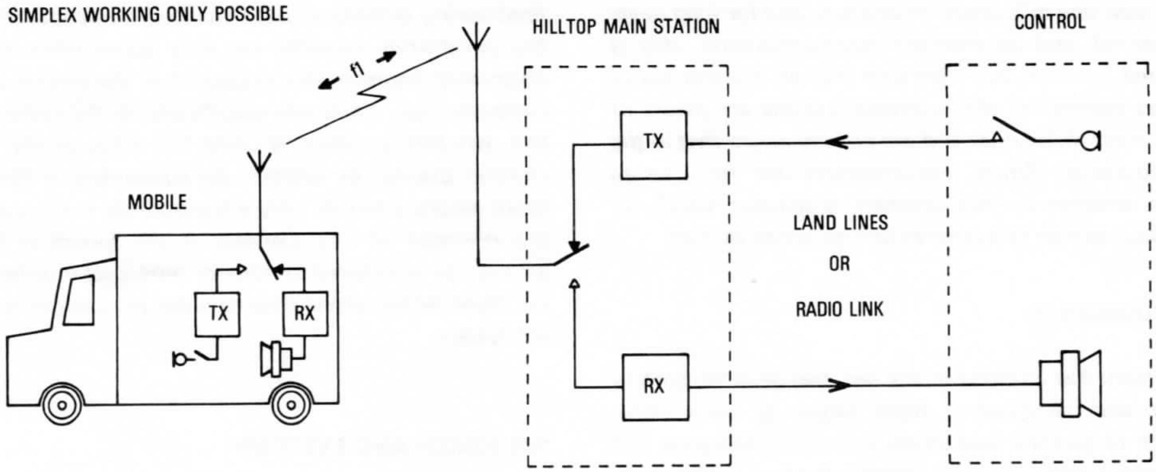
DOUBLE FREQUENCY WORKING SIMPLEX

Fig.10

Engineering techniques have changed tremendously, but the worthwhile benefits are only appreciated by the observable improvement produced in the service to the customer/user. To return specifically to the radio problem, whether a system is using 12½ KHz, or any other channel spacing, or whether the equipment in the back room weighs a ton, or only a few pounds, matters not to the operator at Fire Control, if the speech is harsh, garbled, or smothered in noise or broadcast interference. On these factors alone does he judge the performance of the system.

SALESMEN AND SYSTEMS

There is nothing magical about radio transmission. The basic laws are rigid. But some salesmen would have you believe otherwise. Comparison between commercial systems and Home Office schemes has often been made, but upon analysis has frequently been found to be based upon dissimilar system parameters, or upon different interpretation of operational requirement. Commercial concerns are not endowed with any special knowledge, techniques or resources to which we in the Home Office do not have access. They do, however, possess a quality which we, by our very nature, lack—Salesmanship, which must justify itself upon principles of necessity different from our own. We in the Home Office must admit to being poor salesmen, and are further hampered by the inevitable restraints present in all government organisations, the inability to make immediate decisions involving public expenditure, especially where large capital investment is involved, or to direct staff activities as effectively as commercial concerns. On the other hand, there is a great deal to be gained from the corporate interests, protection, and resources of the overall umbrella provided by the central and regional



SINGLE FREQUENCY WORKING

MOST ELEMENTARY SYSTEM POSSIBLE

Fig. 11

organisation of the Home Office in terms of research facilities, standardisation, co-ordination and compatability of systems. The truth is, of course, that we do use the resources of the radio industry to the full, drawing upon their skill and competitive expertise, and encouraging development and research within the industry on our behalf. The subject is, in fact, one which is frequently a source of discussion between ourselves.

The deliberations of the Central Police and Fire Brigades Communications Committees are proving of great value in establishing common requirements and standards over the whole range of subjects involving communications. Long-term planning for communications systems is also receiving the attention of the Forward Planning Sub-committee, anticipating the use of data transmission in place of speech for routine traffic, facsimile, selective calling, vehicle location systems, and so on. However, the application of the majority of these facilities presuppose the existence of a solid two-way transmission system throughout the area, so again we are forced down to earth to acknowledge the need for a solution to the present coverage problem first of all.

A RELIABLE COVERAGE SYSTEM

Now let us look briefly at some of the factors involved in trying to establish a complete and reliable coverage system, and how to determine the best possible solution. There is the present Home Office type of AM multi-carrier system (Figs. 7, 8) giving simultaneous transmission, which even with the odd filler station may not and, in fact seldom will give 100 per cent cover of a difficult area. I mentioned earlier that the possible poor quality experienced in areas of roughly equal signal strength was one of the disadvantages of this system, but a point I have not stressed is that as channel separations

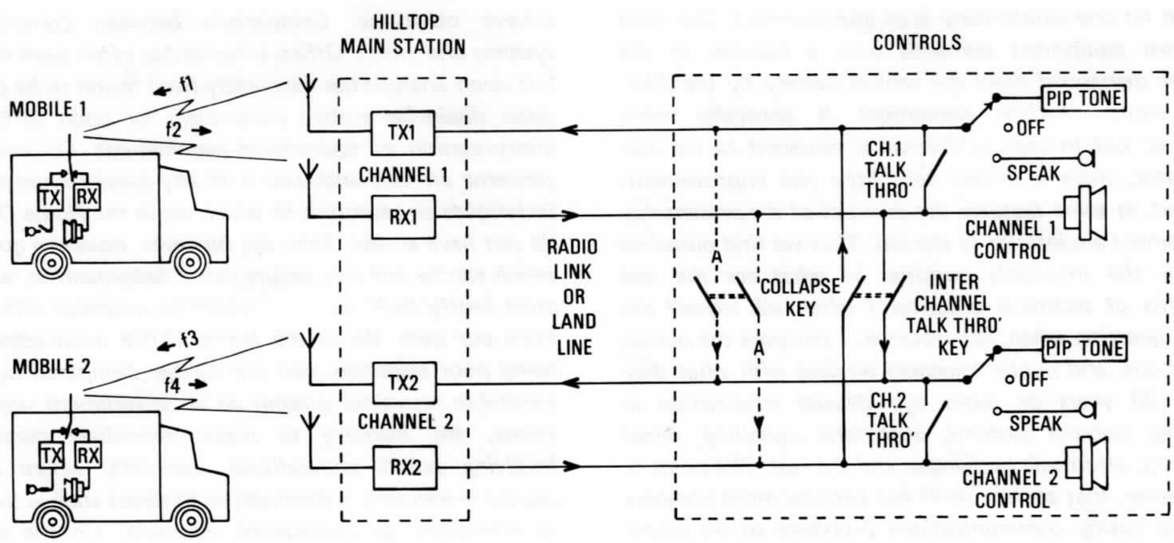
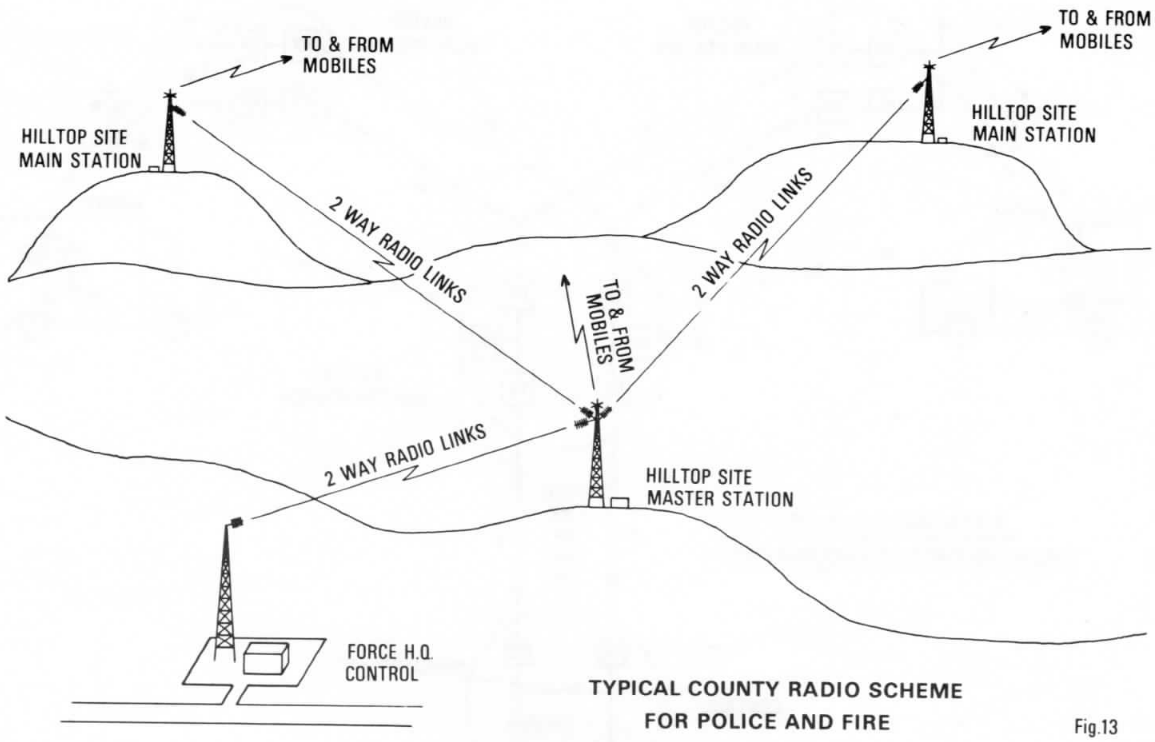


Fig. 12

INTER CHANNEL TALK THROUGH

WITH OWN CHANNEL TALK THROUGH & COLLAPSE FACILITIES



TYPICAL COUNTY RADIO SCHEME FOR POLICE AND FIRE

Fig.13

become smaller, these systems may have to cease altogether to give way, so far as AM is concerned, to methods employing a single frequency for transmission which does not require the bandwidth of a spaced carrier system (Fig. 17). We are now obliged to consider the introduction of 12½ kHz separation for our future planning, whereas the present schemes require 25 kHz for at least reasonably satisfactory operation.

SELECTIVE TRANSMISSION

In order to cover a large area with a single frequency the only really satisfactory method, where AM is concerned, is to use a selective transmission system in which only the transmitter covering the immediate area involved is either energised manually by the control operator, or otherwise automatically by the location of the calling mobile. The limitations of this method are apparent, especially in the event of multiple incidents over a large area. At this stage, it should be mentioned that the actual coverage determination for typical irregular terrain, and particularly over very hilly regions, is quite a complex matter, further complicated by the necessary restrictions imposed by the authorities on the use of sites and aerial masts. Practical coverage tests are invariably necessary to verify the theoretical calculations, and again, on analysis of the results, we are forced to a compromise decision on the siting and engineering of the stations. A selective transmission system may, however, use any reasonable number of low-power transmitters on the common frequency to cover a large area, and this simplifies the problem (Fig. 18). If you are prepared to accept its operational limitations, this is undoubtedly the best system to use, but it must be stressed again that, on this basis, normally only one transmitter can be used at any one time; therefore, the pip-tone channel engaged signal and main station transmission will not be heard by all mobiles throughout the complete scheme area, and talk-through facilities and broadcast information will be restricted.

RECEPTION OF THE MOBILE

In any kind of scheme, reception of the mobiles may, of course, be assured by maintaining continuous operation of all the main station receivers which are permanently connected back to the control station. A selective transmission system of the type described above, can be automated to some degree to ease the strain on the operator, in that the transmitter serving the area from which a mobile calls may be electronically associated with the receiver giving the strongest signal, and thus selected automatically for transmission (Fig. 19).

The method of connecting receivers together is not really quite so simple as it may sound, because a mobile call may arrive via two or more receivers, and the overall quality becomes a combination of the good and bad signals including noise. Thus it is likely to be degraded in comparison with the signal arriving from the receiver nearest radio-wise to the calling mobile. Selective receiver systems, or voting systems, as they are sometimes called, may therefore be employed which allow only the output from the receiver accepting the best signal to reach the operator. All other receivers are then shut off during the mobile transmission. Even this method has some disadvantages, in which are included the risk of one mobile capturing reception from another.

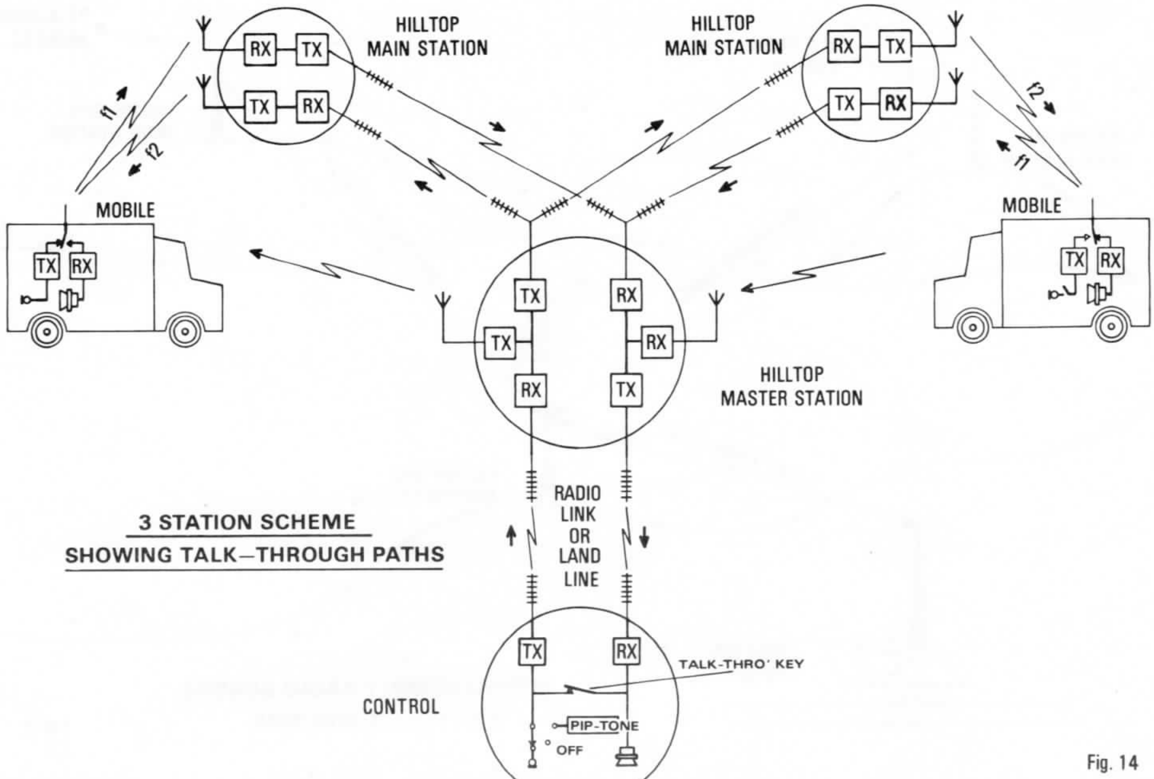


Fig. 14

FM AREA COVERAGE

In discussing selective transmission systems, I have related my remarks to the use of AM. Yet such systems may be applied even more effectively to FM. But the position with FM has changed to the extent that it is now feasible to meet both the simultaneous area coverage requirement and the need for reduced channel bandwidth, by its use for main schemes, to give systems less susceptible to the worse effects of the AM multi-carrier technique, ie the inter-station beats and distortion. It would be wrong to pretend that this method offers a perfect solution to the fundamental problem, but it certainly promises to afford a healthier compromise, and there are systems in existence which bear testimony to its feasibility. I would go so far as to express the opinion that we may be forced to do some serious re-thinking on this subject, especially now that

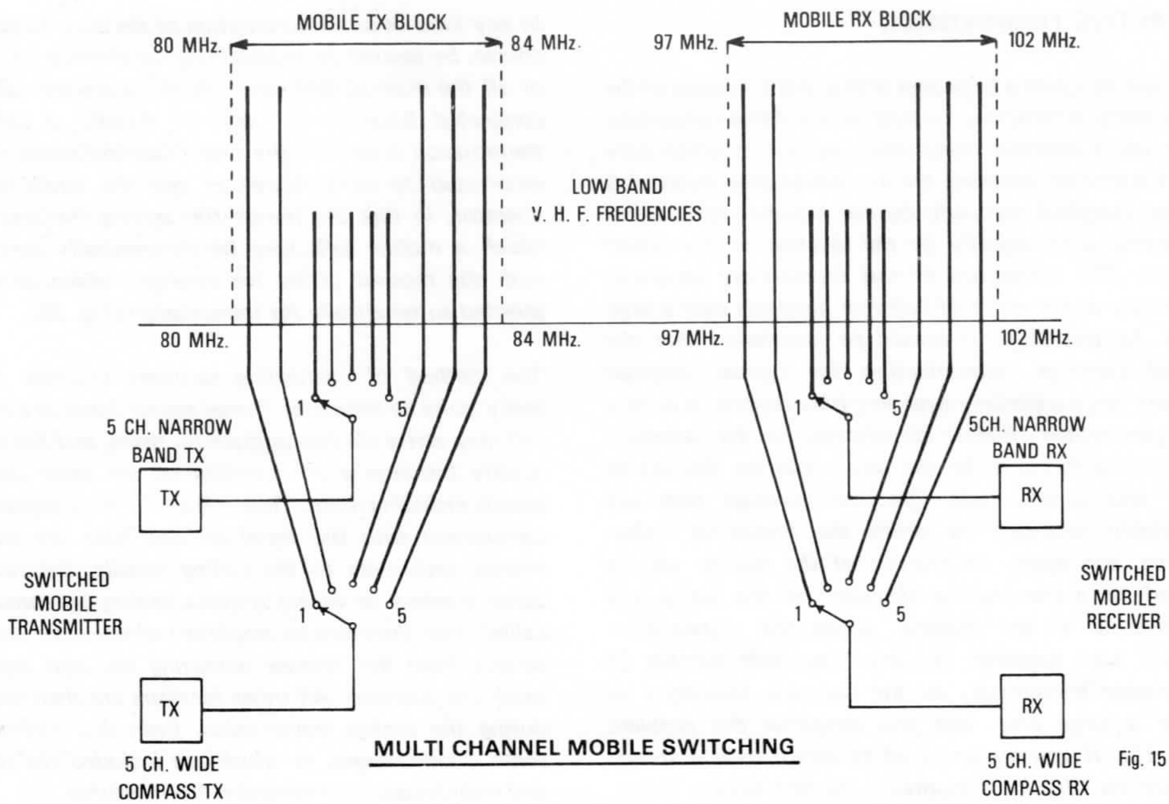


Fig. 15

DIAGRAM "A"
SHOWING HOW THE "AF 101" SET IS INSTALLED IN COLUMN CONTROL UNIT

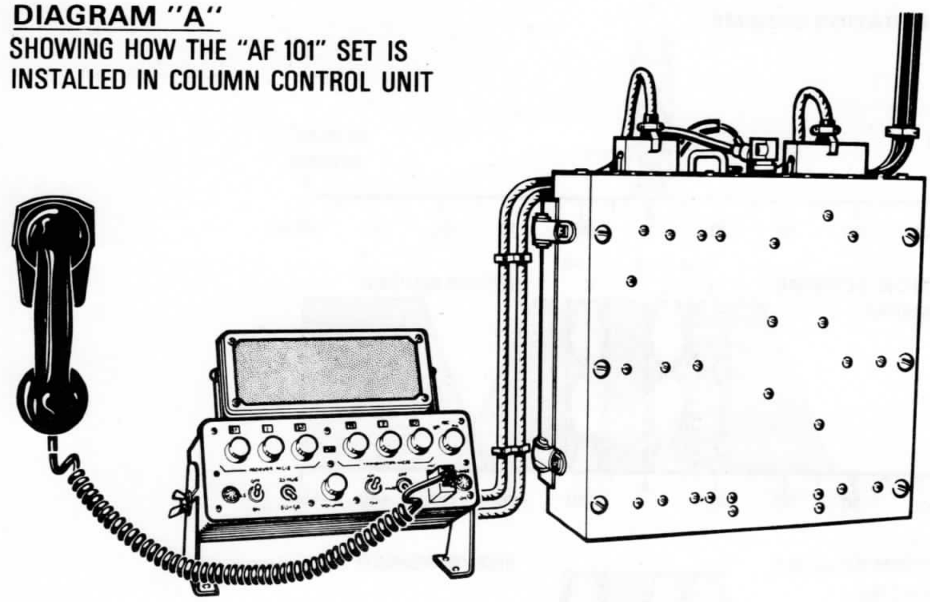


DIAGRAM "B"
CONTROL BOX OF THE "AF 101" TUNABLE MOBILE RADIO SET

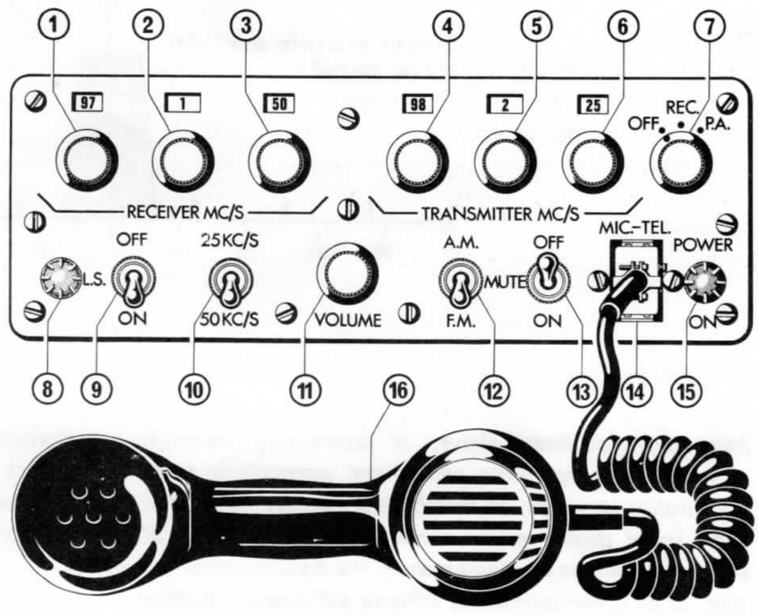


Fig. 16

we are faced with the possibly extensive rearrangement of brigade areas which, one may conclude, could prove to be an opportunity to introduce a change to a new technique.

By now it will be realised that the whole question of large area coverage involves problems which at times are seemingly insoluble. Over a considerable period, possible solutions have been tried by industry, police and fire forces on their own, and the Home Office, and one is faced by the daunting fact that none can claim to have achieved perfection. If unlimited frequencies were available, the position would be much improved. We would then, I feel, be left with problems of an operational rather than technical nature. Again it is all a matter of 'compromise'. So far as cover is concerned, we are, in fact, constantly in search of a satisfactory new technique, but none appears at the moment to be immediately available.

RELIABILITY AND CONTINUITY OF SERVICE

In order to meet the requirement for maximum coverage, the basic system engineering applied to Home Office schemes has usually allowed very little for deterioration in the performance of equipment, mainly because of both economic and engineering factors, some of which

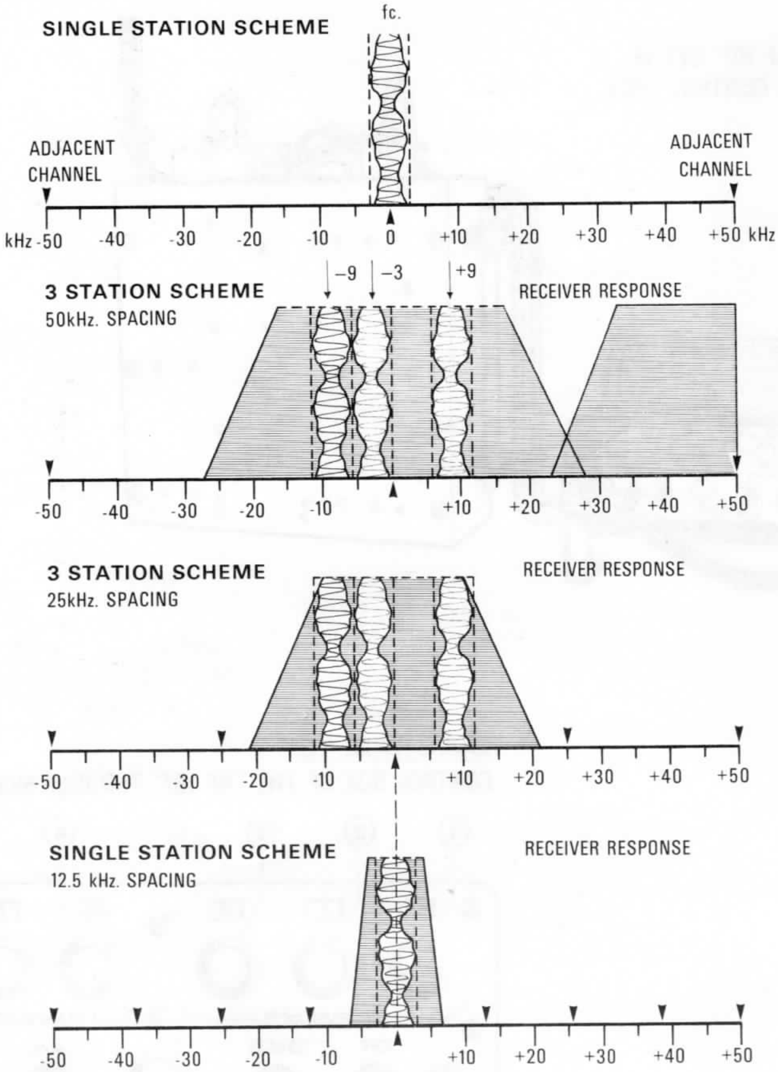


Fig.17

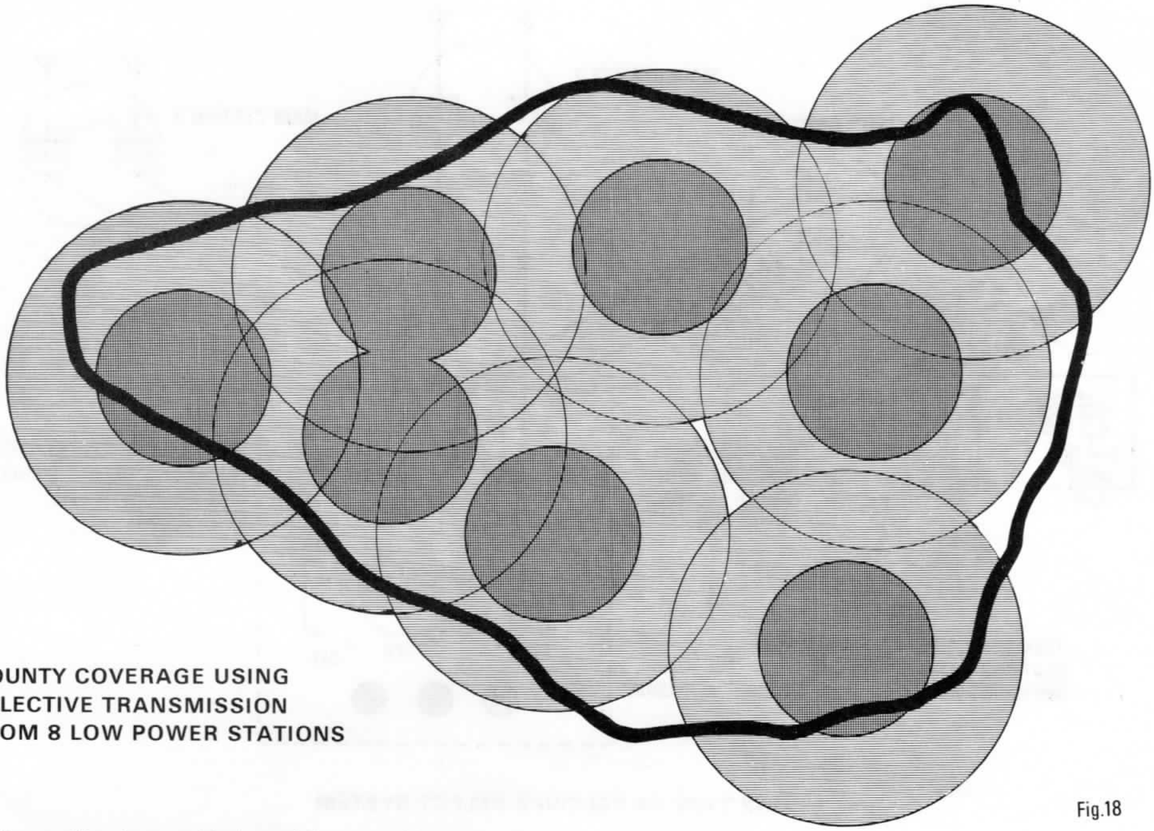
have been outlined above. If satisfactory coverage depends upon operating equipment, particularly fixed and mobile receivers, to threshold sensitivity limits, and then some deterioration occurs, say due to lack of proper alignment or maintenance, the consequences are dire, as all communications officers will know. To allow a fair margin for run down, we ought, in fact, to design our systems to a median figure of something like 5 micro-volts. This is about four or more times the figure we are obliged to accept at present, and within line of sight conditions, would call for transmitters of some 16 times the power of those at present used in order to restore the cover related to this lower sensitivity. This would obviously be a detrimental and uneconomic step, unsound from the engineering viewpoint.

The greater the stability and reliability of equipment, the lower the margin we need allow for run down; this is where well-designed, solid-state equipment, properly protected and robustly housed, can pay dividends. Such equipment invariably costs more to produce, but the additional cost may well be offset by savings in maintenance and certainly justified by the improved service overall. These, I feel, are points to be considered very seriously when the relative merits of equipment in relation to cost are reviewed.

'SAFETY OF LIFE'

On the subject of the continuity of the basic service, one must turn to the case in aviation, where the requirement is for absolute no-break service of RT communication with aircraft. Safety of life is of course the underlying motivation justifying the ability to restore service immediately in the event of failure, and therefore calls for complete duplication of equipment.

Aerials, feeders, transmitters, receivers, radio links, and lines are all duplicated, and for the most important services, a third line emergency is also installed. Not only are belt and braces provided, but also a piece of string for good measure. The limitations of our own systems are unfortunately too often defined by cost and only



COUNTY COVERAGE USING SELECTIVE TRANSMISSION FROM 8 LOW POWER STATIONS

Fig.18

minimal standby is provided, aerials are seldom duplicated, de-icing arrangements are seldom applied. Lines serving radio systems are in few instances duplicated or provided with alternative routings. System failure of a link path is covered usually by a temporary reversion to talk-through at a hill-top site, but this is only a partial expedient to maintain a form of service during link breakdown. Power supplies (which normally are under the user's own control) are not consistently provided with standby generators, nor even obtained from an essential service grade of distribution, as distinct from the normal domestic service wiring of premises. It all seems to be a matter of cost, and it is for the customer to weigh the cost against the requirements of the Service Communications System and the safety of life factor. For our part we can, of course, install or supply anything required provided the money is forthcoming.

USER CO-OPERATION

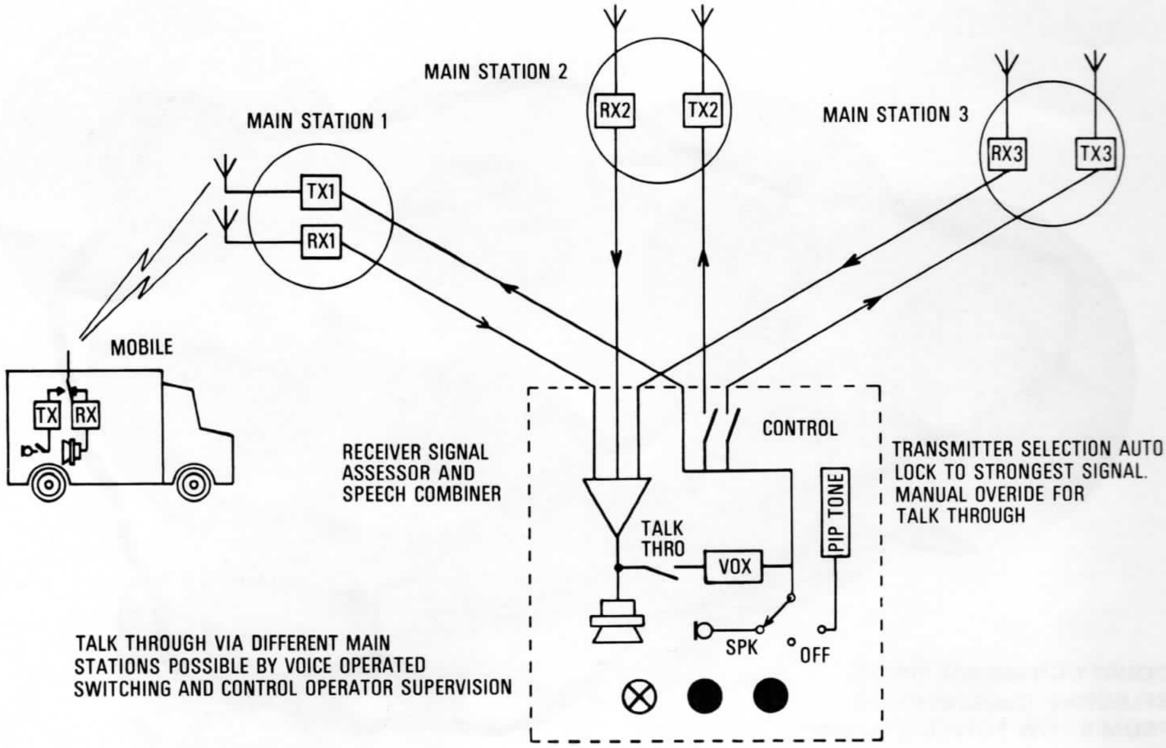
Despite the apparent shortcomings of the present systems from the point of view of having to arrive at compromise engineering solutions, there are a number of ways in which the degree and quality of service can be improved. Apart from the standard of engineering maintenance provided by the Home Office, these are aspects almost entirely within the control of the Service itself. I refer now to vehicle and control room environmental conditions, operational discipline, attention to clarity and brevity of speech, co-operative and prompt fault reporting, implementation of first line restoration facilities by control room staff, constructive suggestions for the improvement of schemes, and so on.

VOLUME COMPRESSION AND MICROPHONE USAGE

Now let us look at a few of the points involved. Many transmission systems are provided with a form of volume compression which enables the outgoing speech level from the transmitters (and thus the volume of reception in the mobile receivers) to be maintained even if the control room operator varies his voice level or speaks too far from the microphone. Some operators, knowing this, tend to become careless or lazy. Unfortunately, if the room noise of typewriters, teleprinters, teacups, and background chatter is high—all of this is amplified and contributes to the degradation of message quality. The remedies are obvious—good, quiet control room conditions, purpose-built consoles, and proper operator discipline. The choice of headsets, handsets, desk microphones, loudspeakers, must suit the environment. Noise cancelling microphones, and indeed all other types, require the correct mode of use to realise their full potential of performance. The noise-cancelling microphone demands particularly careful use. It should be held approximately half an inch from the lips. It is almost useless if held sideways to the mouth or at too great a distance.

MOBILE OPERATOR DISCIPLINE

The requirement for good mobile operating discipline is perhaps even more stringent, especially in relation to microphone usage. There is also a good deal that can be



ONE TYPE OF RECEIVER SELECT SYSTEM Fig.19

done to improve the suppression of vehicle electrical interference from ignition, dynamo, windscreen wipers, etc. This is most important to reception in weak signal areas.

AERIALS

There is too, the matter of the mobile aerial system to be considered. Just as for fixed station aerials, the highest unobstructed position is the best with a good metal base surround, or ground plane. But often a preference is stated for a wing aerial or for one above the windscreen which often finds itself almost horizontal. Both seriously jeopardise the system coverage.

CONTROL ROOMS

There is much that can be done towards the provision of better control room facilities, especially in the design of technical furniture and operating controls. To an extent, so far as radio is concerned, we have tried to standardise on a form of key and lamp unit with various types of desk back-up equipment to control Service radio systems, but most desk installations have in fact been tailored to satisfy cost limitations and have not always been ideal. I would like to see a standard control desk design backed up by a standard radio distribution system, affording complete flexibility and expansion capability of operating positions, irrespective of the number of channels or remote controls, or the type of acoustic and control devices favoured—loudspeakers, headsets, handsets, desk microphones, foot switches, and so on. In aviation, these needs were recognised long ago as essential to safety, and served to ensure thorough familiarity by operating personnel who frequently moved from station to station. Such mobility, I am told, is not unknown among police and fire personnel.

Quality is the essence so far as the end product of a communications system is concerned, and we have received much criticism about the lack of quality of speech over our systems. What is really meant is that the need exists for the best 'intelligibility' rather than hi-fi quality. So long as the message is clear and free from excessive background noise, and is positively intelligible, it does not so much matter whether you recognise the operator's voice or not. In fact the pitch of the voice may be deliberately transposed without affecting its intelligibility. We may introduce deliberate frequency distortion of the natural pitch of the voice in order to improve the intelligibility—to give more attack, but without harshness. This is why the female voice is so often preferred for communications links as it is found that the higher pitch tends to override the effects of a noisy background.

Vital though it is, I will make no attempt to go into the subject of maintenance here, for it is a subject in itself *and will no doubt be treated separately in a future issue of INTERCOM which will describe the efforts being made in the Directorate to improve the general standard offered. In this article, no attempt has been made to go further than the first step in an account of the Directorate's telecommunications problems, but I hope that I have gone some way in creating an appreciation of the fact that some degree of compromise may have to be accepted in our efforts to meet your ideal operational requirement, which indeed, may have to be tailored to what is technically and economically feasible.*

AN INTRODUCTION TO MOBILE TELEPRINTERS

E B Thomson

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The current practice in mobile communications systems is to convey intelligence by natural or, occasionally, by cryptic speech, and it is unlikely that speech will ever be supplanted for short emergency messages in which voice inflections can impart a sense of urgency. However, for a number of reasons involving issues of channel occupancy, channel capacity related to bandwidth, attainable operational efficiency, and other aspects, the routine or lengthy message and the message that requires privacy could best be handled by data communications techniques.

Channel occupancy in this sense means time of transmission which, for both speech and data, is easily measured. A radio channel designed to carry speech signals, providing it is not unduly noisy, could be used to greater advantage for data communication. Messages sent out in data form are in code, so that the radio scheme needs encoding equipment at control for message origination and decoding terminals for its reception. The receiving terminals for a mobile radio scheme would be vehicles fitted with compact teleprinters connected to the receiving portion of the combined transmitter/receiver.

BANDWIDTH

The bandwidth of a communication channel is the space it occupies in the relevant audio or radio frequency *spectrum. The channel has upper and lower limits of frequency, and its bandwidth is the difference between those limits. A signal passed over the channel must not spread in frequency beyond the channel bandwidth if distortion and interference between adjacent channels is to be avoided. Radio transmission techniques during the conversion processing of the signal from audio to radio frequency, except in special cases, double, or more than double, the effective spread in frequency of the basic signal, so that the radio channel must be accordingly wider.*

Voice signals, allowing for the different pitches and enunciation of various speakers, spread in frequency from 300 to 3,500 Hz, requiring a prerequisite bandwidth for transmission over line or radio. When a person speaks into a microphone, the electrical voice signal has time intervals between individual sounds, and these intervals are shortened during fast speech. However, the rate of speech, whether fast or slow, does not effectively alter the limits of the frequency-spread and hence the overall bandwidth required. On the other hand, in data transmission, the rate of information and channel bandwidth are directly related. If the speech message is put into written form and a precise data code is allocated for each alpha/numeric code, it is a very simple matter in principle, if not in application, to transmit in data all that can be said by an extremely fast talker (at, say, 200 words per minute) in half the time and within a very much narrower bandwidth.

The reduction in bandwidth, much prized in congested communication bands, is the important feature, since it allows more avenues of communication to be accommodated in a particular channel or, conversely, more channels in a certain bandwidth. Time-saving in data communications is more abstract because, although the chief economy is in channel occupancy, it is offset to some extent by the time taken for message preparation.

SIGNALLING IN DATA

A block of information in 'data' is characteristically transmitted in spurts of electrical impulses with varying size of gap between the impulses. Both the impulses and the gaps within the blocks have meaning and provide a two-state or binary level of signalling, namely On or Off. This signalling form, for teleprinters operating over radio circuits, is modified to use audio frequency tones. This means, in practice, that one tone frequency, say 1,000 Hz, is the impulse and another frequency, say 1,800 Hz, is the gap. Each gap or impulse must be of defined length or duration since, in the coding of each block of information, several gaps or impulses may be put together in sequence.

In teleprinter terminology, an impulse is known as the 'A' Condition, corresponding to the On or active state, and a gap is called the 'Z' Condition for the Off or inactive state. These are written as 1 and 0 respectively in binary code. Each alpha-numeric character of the message is composed of its own individual combination (or information block) of five or seven consecutive 1s and 0s, dependent on the code used, and transmitted as precise duration bursts of each tone frequency.

Another tone frequency, say 1,500 Hz, is transmitted at the beginning of the message to start up the remote mobile teleprinter.

When data is being sent to the mobile teleprinters, a listener on the radio network would hear a continuous musical warble as the signal rapidly changes from one tone to the other.

Most of the teleprinters available, all of which are designed to operate within a speech channel of 300 to 3,500 Hz, do not allow the simultaneous occupancy in the channel of speech and data. It is thus speech or data, but not both together. Combined speech and data working at a comparatively slow rate of 50 baud for the teleprinter (Telex speed) is made possible by electrical filtering and a suitable choice of tone frequencies. At least one teleprinter manufacturer offers this combined facility in his design. Generally, however, it is not technically feasible to squeeze, for other than slow data, both types of information simultaneously into a mobile radio speech channel without suffering unacceptable degradation in speech quality. This channel-sharing may not always be necessary for, when working at an upper speed (for mobile teleprinters) of 30 characters/second, quite a long message may be sent in a few seconds and so not greatly disrupt the use of speech communication. Also, the system may permit the data message to be temporarily suspended for speech break-in and later renewed without loss of copy.

At the slower data speed of 7.5 characters/second, the chief drawback of the use of mobile teleprinters in a radio speech channel is the disturbing effect to the recipients of the tones used in the data transmission. This can be minimised by selective addressing.

SELECTIVE ADDRESSING

This is a means by which individual vehicles, or groups of vehicles, including all vehicles in a mobile radio network, can be selected for message routeing.

The system, which also employs audible tones arranged in an addressing code, inhibits the receipt of a message by any other than those for whom it is intended, a facility which makes it attractive for data communication over a speech radio network. Also, its provision, a muting action, can be automatically placed on the *loudspeaker circuit of the mobile radio receiver during data transmission. Data messages can be recorded at the mobile when its crew is absent, and may be either automatically acknowledged by the selective addressing system or manually by the crew on return.*

PRIVACY

Data transmission to mobiles imparts a fair measure of privacy since the radio channel transmissions are unintelligible to the random listener.

CHARACTER FORMATION

At the mobile teleprinter, dependent on the system adopted, characters may be impact or non-impact printed in one of two ways, either as written by a conventional typewriter or built up by a combination of closely spaced dots. The latter method operates on the dot matrix principle and is so called because the printhead of the machine selects and imprints dots singly or several at once, within a matrix formation (possibly 7 x 5 = 35 dots) to form the shape of the character.

A 7 x 5 matrix can be regarded as an imaginary grid formed by five equally-spaced parallel vertical lines intersected at right angles and enclosed by seven equally spaced horizontal lines. The dots are placed at all points of intersection of the imaginary lines.

There are wide variations in the dot incidence for the print-out of characters; for example, to print out the letter B in a 7 x 5 matrix could take 20 dots, whereas a 1 would only require seven. This method appears at first sight to be cumbersome, but there are good reasons for it. All communications systems suffer to a greater or lesser degree from noise, which in sufficient intensity will degrade the system performance and, for data messages, create errors resulting in a change of information. If such a transmitted 'block' of coded information signifies a complete character, then any appreciable alteration produced by noise may result in character error. By sending out much more information for each character (in effect, to pin-point the individual dots) the probability of loss or change of character is greatly reduced, since the omission of several dots may not, in itself, lead to confusion in character recognition.

At the expense of the additional bandwidth required for any given print-out speed, the system is then deemed to be more tolerant to high noise conditions and is said to make use of 'redundancy'. This is a term used to signify that more information is transmitted for error-masking than is strictly necessary. Not all matrix-type printers depend on 'redundancy' transmission for their operation—the choice then for the print-out method being based solely on mechanical considerations.

MESSAGE ORIGINATION

At control, a message could be prepared by an operator/typist on a tape punch machine to provide both a print-out of the message and a punched paper tape, which most probably would be in the International Telegraph Alphabet No 2 code employed for Telex and other data communication. The punched tape would then be fed by the operator into a tape transmitter directly connected to a code translator for the conversion of the message into a suitable signalling form for onward transmission over the radio scheme. Except for the code translator, this equipment is similar to Telex and has the same limitations in dealing with errors incumbent during message preparation. A more flexible system for message origination makes use of a device known as a visual display unit (VDU) and offers considerable scope for manipulation by the operator. A VDU has an in-built computor-type store (or register) whereby, instead of message-proof print-out on paper in front of the operator, the information is presented on a TV tube display. The entry keyboard is as a typewriter for setting up the message on the screen, but any errors or redundant information can be instantly deleted or altered. When the operator is satisfied with the content of the message, he has the choice of forwarding it or placing the information in temporary storage for later transmission.

A VDU may also be pre-programmed to give routine message headings of Classification, Date, Time, etc, to ease work tedium. The operator does not need personally to maintain a hand-written log for record purposes, since the device can be connected to a more permanent storage system such as magnetic drums or discs or, if required, to a nearby fixed-installation teleprinter for print copy. The various facilities of a VDU terminal are much too numerous to discuss here and indeed, because of its extreme versatility its cost can be high compared to the more modest Telex-type terminal. A VDU typically has an output signal in the seven-unit International Telegraph Alphabet No 5, allowing more individual code combinations than ITA 2 but, as before, its output has to be put through a code translator for conversion into suitable signalling form for transmission over the radio channel to the mobile teleprinter receiving stations.

CLASSIFICATION OF MACHINES

For mobile use, there is not at present a great deal of choice of teleprinters. There are, in fact, fewer than 10 different models available from European or USA markets. The price range for a single machine, complete with its decoder, exceeds the cost of a typical VHF mobile radio installation by 50-100 per cent.

All the machines fall into either of two categories—impact or non-impact types. However, they can be further classified into their various methods of producing print copy. As would be expected, impact type machines are the noisier breed, but this feature is greatly dependent on the mechanical system employed for print formation. The alpha-numeric character is printed by a print wheel or probe (in matrix print-out) on to paper sensitive to pressure, or through an inked ribbon on to ordinary paper. Impact printing allows simultaneous multi-copying, not usually possible by non-impact methods, and up to four copies can be obtained by the use of pressure-sensitive manifold paper. Rapid repeat copying without the need for further transmission is a possible feature of non-impact models.

Non-impact printers can be sub-divided into four main categories:
(1) electrostatic;
(2) electromagnetic;
(3) electrothermal;
(4) character formation by electric arc.

In electrostatic machines, the paper is given an electrical charge by a moving stylus in a pattern corresponding to the shape of the letter or numeral and then developed by the application of a chemical toner. The result is made permanent by passing the paper over a heated plate. Fast and near-noiseless print-out is achievable by this method, but only for a single copy. Instant reading of the message is not possible due to the short delay imposed by the heat process.

In the electromagnetic system, alpha-numeric characters are recorded on the surface of a magnetically-sensitive material in much the same way as a tape-recording. This surface is then passed through a powder consisting of resin-coated ferrite particles. These are attracted to the magnetised areas and, in turn, deposited by close contact on to paper to give the print-out. The print-out is made permanent by heat which melts the resin. As in the electrostatic method, the print-out is practically noiseless and extremely fast. There is also the facility of repeat copying until the information is erased.

The electrothermal method has character-forming by localised heat from the print head on to a heat-sensitive paper, whereby the colour of the paper alters at the point of heat application. There is fast noiseless action for a single copy only.

In the technique of character formation by electric arc the character is formed by application to a metallised paper tape, the metal being removed by the heat of the arc to form the character.

Print-out speeds for the various categories of the teleprinters listed are typically 7.5 to 30 characters/second, but electrostatic deposition machines, in particular, are capable of operating at speeds above 150 characters/second. There are other types of teleprinters working on the inkjet or electrochemical and electro-optical principles, but these have not yet been adapted for mobile use. For compatability, the mobile teleprinter must operate from a 12-volt battery supply, and certain features such as solenoid-actuated probes for print-out, synchronous motor carriage drive, thermal print head, etc, raise problems which have simple solutions in mains-operated equipment. A mobile teleprinter must also be capable of operating under less stable conditions of both vibration and temperature.

The machines print on roll paper or on paper tape. Roll paper is mostly adopted, with no obvious standardisation of width, although in some cases it can broadly be classified as half-page in comparison to a standard desk-top teleprinter.