Copyright Notice

Crown copyright material is reproduced with the permission of the Controller of HMSO and the Queen's Printer for Scotland

All material contained in this document was scanned from an original printed copy of Exhibition 1971 Leicester produced by the Directorate of Telecommunications in September 1971.

The licence granted by HMSO to re-publish this document does not extend to using the material for the principal purpose of advertising or promoting a particular product or service, or in a way, which could imply endorsement by a Department, or generally in a manner, which is likely to mislead others.

No rights are conferred under the terms of the HMSO Licence to anyone else wishing to publish this material, without first having sought a licence to use such material from HMSO in the first instance.

Signed

Steven R. Cole
22nd October 2004

"OLD HAT - OR FOOD FOR THOUGHT"?

GENERAL ASPECTS OF GROUND MOBILE COMMUNICATION SYSTEMS

By: J P Titheradge CEng MIERE

(This paper is reprinted, with slight amendments, from the paper presented to the Chief Fire Officers' Conference at Dorking, 9 June 1971.)

The use of radio for mobile speech communications systems has been seriously exploited for more than 40 years. Some of you will recall the early medium frequency installations upon which the sitings of the Home Office Regional Wireless Stations were based. These original stations (Fig 1) now perform the function of Regional Maintenance Depots. Medium frequencies were in fact used far more than is generally realised for mobile communications, particularly in the USA, and for air/ground systems throughout the world. However, there were many adverse factors associated with the use of medium frequencies for ground mobile purposes, eg equipment performance, aerial requirements, and propagation characteristics.

You will have noticed what happens to broadcast reception on your own domestic receiver or car radio when tuned to the medium waveband, particularly during the hours of the evening and night when considerable variations in range and quality occur, giving rise to foreign interference, selective fading, and other unpleasant effects. These effects result mainly from the nature of the propagation path followed by the waves, and the manner in which the ionosphere affects them. Now 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; it follows the line of sight as we term it. 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 ft 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 as you know from your TV reception, and probably also from experience with your own VHF mobile radio schemes. This is where nature holds the whip hand, and we begin to realise that we can do nothing to alter the basic laws of propagation.

Frequency Spectrum

I have already referred to frequency and wavelength and to various parts of the frequency spectrum, and as I shall be doing this throughout my talk, it may not come amiss to refresh your memories on the basic range of the spectrum and the uses to which it is put. Figure 2 illustrates the whole spread of the spectrum from zero frequency, or d.c. as we know it electronically, through power supply and sound frequencies, to radio in 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, minor battles being waged over the relative merits of amplitude and frequency modulation as side issues. More of this later however.

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. It was during this period that the Home Office embarked upon its major development and installation programme for police and fire services, and by 1952 substantial areas of the United Kingdom were equipped with mobile radio schemes. At this stage I think it would be as well if I were to say a few words about amplitude and frequency modualtion, the two main modulation techniques at present employed for the majority of our mobile communications systems.

Amplitude and Frequency Modulation

The basic link between the transmitter and the receiver is a carrier wave generated in the transmitter, upon which variations conforming with the speech or intelligence to be conveyed are impressed. 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. I should mention that the carrier wave may be varied in several other ways to convey the same intelligence, but I will not attempt to describe these 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.

Early choice of AM

With regard to the general nature of AM and FM, however, there are several fundamental differences which influence the choice of one or the other for specific applications. 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 RT 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.

Despite this however, there was one major reason which influenced the Home Office choice, and incidentally 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 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 observed 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 a large area was a fundamental operational requirement of police and fire service schemes, based as they were mainly on county areas, and of course to airways systems for the flight information regions. Hence, for these reasons, AM multi-carrier systems were chosen.

AM and FM characteristics

Now, having said that, I ought to point out some of the differences in the characteristics of AM and FM because we shall need to return to the subject at a later stage in my paper and I want you to be well aware of the main points at issue.

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. Now with the present day reduction in channel bandwidth the difference in threshold performance of AM and FM receivers has become less marked - noise becoming a problem with both systems.

Selective Calling and Public Address

Both AM and FM systems are compatible with selective calling, paging, vehicle location, and remote control 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 activate 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 instance the public address facility usually embodied in the mobile AM transmitter has proved of considerable value to some mobile users - notably the police - and is easy to provide by making use of 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 your systems, although a few AM links still remain which are scheduled to be changed very soon.

Extension into UHF

Now to return to the general radio communications theme. With the ever expanding use of mobile radio for all manner of services the congestion of the VHF frequency bands became acute. (The number of mobiles operating in the United Kingdom now is of the order of 100,000.) The need to extend into the higher frequency bands was 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 industry. It was found that the propagation of UHF frequencies followed even more closely to line of sight than VHF, but possessed slight differences, generally giving 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 pocketfones. The range in the open was usually found to be slightly inferior, but UHF lent itself very well to compact schemes having fairly well defined boundaries, as for instance in the coverage of a city or large town. The suitability of UHF for portable and pocketfone equipment and for fixed radio links as mentioned earlier in conjunction with frequency modulation was very quickly realised and fully exploited. I should perhaps mention that in the UHF bands frequency modulation finds almost universal application. A property of UHF of considerable advantage to the mobile user is its greater freedom from the effect of man-made noise, electrical interference and vehicle ignition interference. You will have noticed the improvement when you switch to the UHF channel on your TV, especially if you live in the proximity of a busy motor route.

Returning to the question of penetration however, I dare not risk being too specific about the relative merits of UHF and VHF for penetration into buildings, tunnels, mines and 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 endeavouring to obtain more information from trials of selected equipment in such environments, with the accent also on the need to choose a suitable radio for use with breathing apparatus. For some environments, VHF appears to be better, and for others UHF seems to have the advantage. We are also considering 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 be determined by factors of cost, weight and compactness of equipment, the size of aerials, whether AM or FM, and of course the question of equipment availability from commercial sources. Looking at the overall situation there is no simple or magical solution to the problem of providing solid two-way radio communications into any type of building, seaborne or underground structure, despite the impressions given by 'Uncle' and 'Ironside' of TV fame!

Incidentally, you will be interested to know that despite the extreme shortage of UHF frequencies, arrangements have been made to allocate two pairs in the pocketfone bands for Fire Brigade use on a country-wide basis. We have not decided so far exactly how to apply and share the use of these frequencies to meet the demands of fireground, BA, paging, and other purposes. This must be the subject of a speedy but detailed study of the operational requirements in relation to the technical issues of range and interference but I fear that we will be obliged to restrict the use of UHF to localised short range applications.

<u>Block Frequency Allocations - Double Frequency Working</u>

The blocks of frequencies allocated for Home Office use are arranged basically in paired bands (Fig 9). This was done deliberately to enable double frequency working to be employed; in fact it affords an overall economy in the use of frequencies and allows the engineer to derive certain technical advantages. To refresh your memories <u>double frequency working</u> (Fig 10) implies a system using one frequency for transmission to the mobile, and another from the mobile to the main station receiver. This separation of transmitting and receiving frequencies minimises interference problems in the form of cross-talk between channels, and simplifies the system design allowing channels to be more closely spaced.

Simplex and Duplex

Simplex working means that transmission of information can only take place in one direction 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 as in the use of the conventional telephone.

Single frequency systems (Fig 11) employing 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.

Single frequency 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 the use of packsets in this manner may well be preferred. 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. All of these points, I think, provide interesting subject for discussion.

Talk-through working

Talk-through working (as featured in Figs 10 and 14) simply implies establishing two-way working between mobiles or outstations via a main station or network of main stations. This allows the advantage in range of the better sited and higher 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, however, is inevitably accompanied by an impairment of quality owing 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 for example of a fire brigade working as a sub-control. If taken into account when the system is planned cheaper shcemes can sometimes be obtained by this method but the pros and cons need to be very carefully considered.

Multi-Channel Operation

Multi-channel operation implies the ability to switch equipment to a number of distinct channels. In the case of double frequency equipment, this of course involves the change, on switching, of both the transmitter and receiver frequencies. Now, for technical reasons, it is much simpler 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 the same number of channels spread throughout the entire width of the frequency blocks allocated to the Home Office. Equipment to perform this latter 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 showing considerable signs of improvement and it is hoped that in the not too distant future moderately priced mobiles will be available to meet this challenge from a number of manufacturers. One such equipment is at present undergoing large scale trials with both the police and fire forces in this country. The position will then be much easier when we come to consider the provision of inter-scheme working and monitoring, but I feel that there will always be a requirement for the simpler and cheaper type of mobile, particularly where space considerations are of major importance. Incidentally the same wideband facilities will be available from fixed station equipment and I predict that this will simplify many of the inter-force communications requirements for peacetime and other purposes.

Operational requirements

Having dealt mainly with principles, I want to come to what is perhaps the main point of my paper. The fact is 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 and complete intelligibility; despite geographical, climatic and environmental conditions, operators' dialect or sex, and with traffic densities from virtually nil to disaster proportions". Just as simple as that!

Over many years, communications engineers have striven to achieve this ideal objective, but the truth is that we are almost as far away from it as we ever were - within practical and economic means. We can fly away, talking or dreaming 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 inevitably we are forced to a hard bump landing, and to acknowledge the radio situation as it 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. To cover an area not unlike a large county the BBC finds it necessary to employ effective transmitter power of the order of half a million watts, and even then must install small low-power filler stations to provide a service in shadow regions, as for instance at Reigate, to off-set the the basic loss of propagation to which I have referred. This illustrates the futility of employing sheer brute forwe power where line of sight propagation is concerned. Quite obviously, for technical and economic considerations, we have to strike a balance and reach a compromise, especially where mobile radio communications are involved.

Frequency allocations and interference

Throughout the contry there is fierce competition for the allocation of frequencies from the blocks available, and we are being forced into closer and closer channel spacings. This gives rise to extremely difficult engineering problems in the battle to exclude interference. The higher the power we use the more difficult the problem. 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. I would like to amplify this point about co-siting.

Separate Sites

It is 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, putting them ideally at least a mile apart. In aviation, and for long range commercial and government communications, this is accepted practice; but where fire and police are concerned, you know the position! I am afraid we may have to face up to the need in the future of doing something to ease our engineering problems in this way, and again of course it amounts mainly to a matter of cost.

Equipment Performance

Now a point or two about performance. Equipment has changed 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 hundred-weight or more of 1946 mobile has been replaced by something weighing only a few pounds; admittedly it demands only a fraction of the power from the vehicle battery and generally possesses higher reliability, but apparently to the user operator, there is in fact very little real improvement in basic performance. Indeed, in some features the qualities of the present day equipment are worse! You may then well ask what are the real benefits of technical progress?

Engineering techniques have changed tremendously, but the worthwhile benefits are only appreciated by the observed improvement produced in the service for the customer/user. To refer specifically to the radio problem, it matters not to the operator at Fire Control, 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. If the speech is harsh, garbled, or smothered in noise or broadcast interference, this is what matters to him, and forms the basis upon which he judges the performance of the system.

Commercial and Home Office Systems

There is nothing magical about radio transmission. The basic laws are rigid enough, but some salesmen might 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. We in the Home Office however must admit to being poor salesmen, and are further hampered by the inevitable restraints present in all government organisations, eg 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. But on the other hand there is a lot to be gained from the corporate interests, protection, and resources of the overall umbrella provided by the central and regional organisation of the Home Office in terms of research facilities, standardisation, co-ordination and compatibility 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.

Area Coverage

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 solution possible.

There is the present Home Office type of AM multi-carrier system (Figs 7 and 8) to which I have already referred, giving simultaneous transmission, which even with the odd filler station may not give 100% cover of a difficult area. In fact it very seldom will. I mentioned earlier that the possible poor quality experienced in areas of roughly equal signal strength was one of the disadvantages of this system. However, a point I have not stressed is that as channel separations become smaller, these systems may have to cease altogether and,as far as AM is concerned,give way 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 $12\frac{1}{2}$ KHz separation for our future planning whereas the present schemes require 25 kHz for 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 energised. This may be done either manually by the control operator, or 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.

I should, perhaps, at this stage mention that the actual coverage determination for typical irregular terrain, and particularly very hilly regions, is quite a complex matter, not made any the easier by the restrictions 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). This is undoubtedly the best system to use, but I must again stress that on this basis normally only one transmitter can be used at any one time, and therefore the pip-tone channel engaged signal and main station transmission will not be heard by all mobiles throughout the complete scheme area. Also talk-through facilities will be restricted as well as broadcast information.

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 I have described can be automated to a degree to ease strain on the operator, in that the transmitter serving the area from which a mobile call may be electronically selected by the receiver giving the strongest signal (Fig 19).

Selective Receiver System

The method of connecting receivers together is not really quite so simple as it may sound. This is 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, and is thus likely to be degraded compared 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, and all other receivers are then shut off during the mobile transmission. Even this method has some disadvantages, including the risk of one mobile capturing reception from another. It is almost impossible to win!

FM Area Coverage

In discussing selective transmission systems, you may have noticed that I have been careful to relate my remarks to the use of AM as opposed to FM although such systems may be applied as effectively to FM.

Need for New Technique

You will have seen that the whole question of large area coverage really does involve problems, and over many years possible solutions have been tried by industry, forces on their own, and the Home Office, but it is a fact that none has achieved perfection. If unlimited frequencies were available to us the position would be much improved, but I suspect we would still be left with problems of an operational rather than a technical nature. Again it is all a matter of "compromise". So far as cover is concerned, we are in fact searching for a new technique, but none seems to be just around the corner, nor just above us - thinking now of satellites! However, in another part of this handbook you will probably read of a new system of mobile communication which offers possibly more than a ray of hope for at least a long term improvement but not, I predict, for a complete solution to the universal mobile problem.

Reliability

I think I should say a little about 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 economic and engineering factors, some of which I have already outlined. If satisfactory coverage depends upon operating equipment (particularly fixed and mobile receivers) to threshold sensitivity limits, then the consequences due to lack of proper alignment or maintenance are well known usually from first hand experience. To allow a fair margin for run down, we ought in fact to design our systems to a median figure of something like 5 microvolts. 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 and unsound from the engineering viewpoint.

The greater the stability and reliability of equipment, then the lower the margin we need allow for run down, and this is where well designed solid state equipment properly protected, and robustly housed, can pay dividends. Such equipment invariably costs more to produce, but this 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 we review the relative merits of equipment in relation to cost.

Safety of Life

Now so far as continuity of the basic service is concerned, I would like to quote 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. In fact they have the proverbial 'belt, braces, and piece of string'.

Now compare your own situation - does the same requirement apply? Apparently not, because cost,as I see it, is usually allowed to dictate the limitations of the system. Only minimal standby is provided, aerials are not duplicated and de-icing arrangements are seldom applied. Lines serving radio systems are rarely duplicated, or provided with alternative routings. System failure of a link path is covered in most cases 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, and this is normally a matter under your 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 you 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 arriving at compromise engineering solutions, there are a number of ways in which the degree and quality of service can be improved, and apart from the standard of engineering maintenance provided by the Home Office, these are aspects almost entirely within your control. 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 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 room background noise such as typewriters, teleprinters, teacups and background chatter is amplified and degrades the 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 of course suit the environment. Noise cancelling microphones, and indeed all other types, require the correct mode of use to realise their full performance, but especially the former,ie the noise cancelling microphone. This should be held approximately half an inch from the lips. It is next to useless if held sideways or at a distance from the mouth.

Operator Discipline - Ignition Interference - Vehicle Aerials

The requirement for good mobile operating discipline is perhaps even more stringent, especially in relation to microphone use. There is also a lot that can be done to improve the suppression of vehicle electrical interference from ignition, dynamo, alternator and windscreen wipers, and you willknow how important this is to reception in weak signal areas. Then of course there is the matter of the mobile aerial system. Just as for fixed station aerials, the highest unobstructed position is the best with a good metal base surround, or ground plane, as we term it. But how often is preference stated for a wing aerial, or for one above the windscreen which often finds itself almost horizontal? Both jeopardise the system coverage.

Control Rooms

There is a lot 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 deskback-up equipment to control your 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 design you favour,eg 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 around from station to station. Such mobility, I am told, is not unknown in the Fire Service!

Quality and Intelligibility

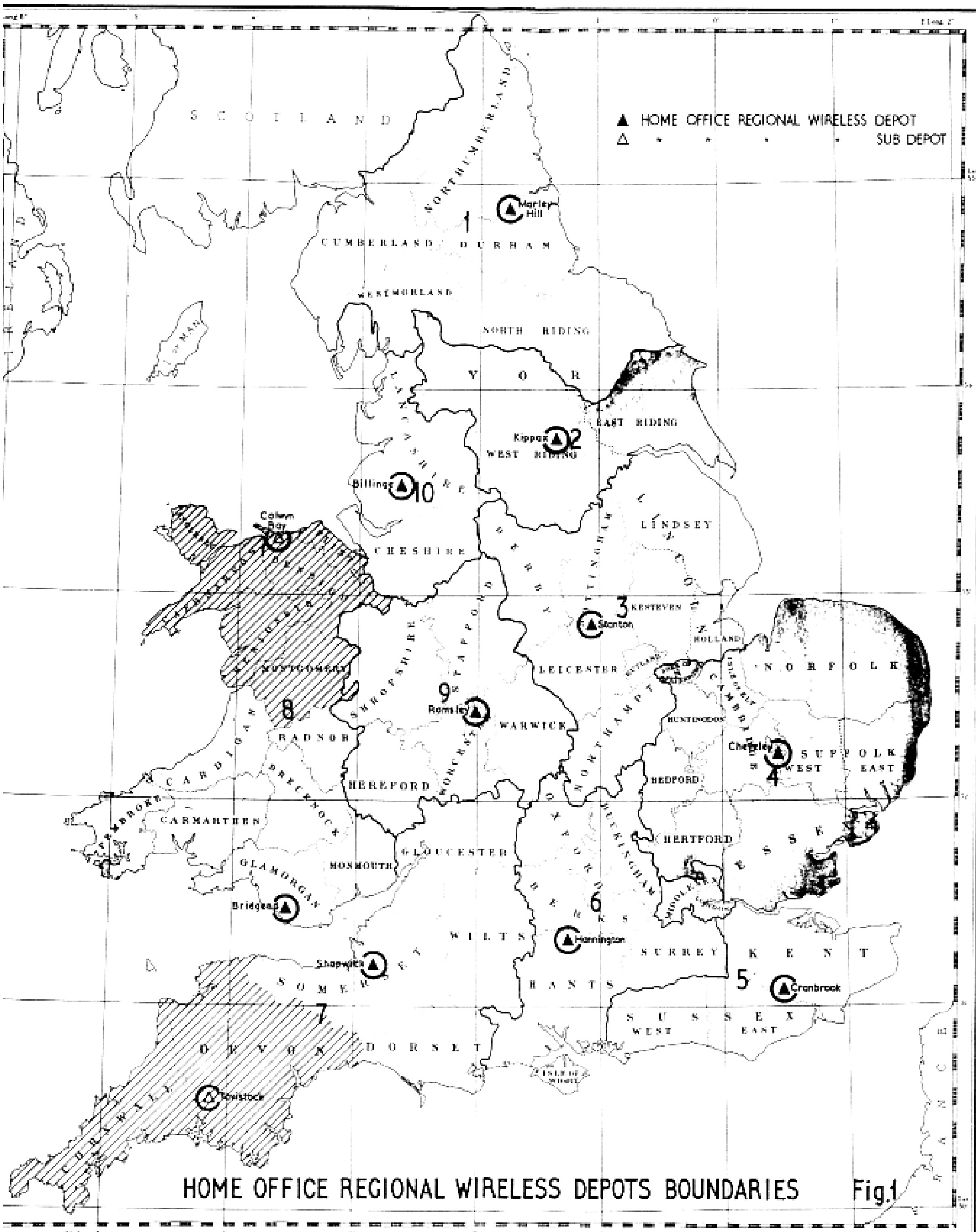
The subject of quality is something I would like to get straight because we have received much criticism about the lack of quality of speech over our systems. What is really meant is that the need exists for the best "intelligibility" rather than Hi-Fi quality. So long as the message is clear and free 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 in fact introduce deliberate frequency distortion of the natural pitch of the voice in order to improve the intelligibility,ie 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.

The Human Element

A great deal of this communications business in fact comes down to the human element in both operation and maintenance. Another paper in this handbook amplifies the question of maintenance, and describes the efforts being made in the Directorate of Telecommunications to improve the general standard of service offered.

I think that is as far as I can go in this paper, but from what I have said I hope that the word 'compromise' will at least have stuck,and you will appreciate that operational requirements must be tailored to what is technically and economically feasible. To this end I trust I have given a little "food for thought".

Mr J P Titheradge served with REME Telecommunications from 1940 to 1946 which included three years as an instructor at The Royal Military College of Science. He joined the Home Office in 1946 as a Chief Wireless Technician working on early design and development of Police and Fire radio schemes, and in 1950 was appointed to the post of Wireless Engineer. Later he transferred to the Ministry of Civil Aviation, working on the development of aviation ground radio systems, and from 1960 to 1970 he was at the Civil Aviation Telecommunications Engineering Establishment at Gatwick as Senior Signals Officer. He then returned to the Home Office to fill his present post of Chief Wireless Engineer for Fire and Civil Defence.



HOME OFFICE REGIONAL WIRELESS DEPOTS BOUNDARIES Fig.1

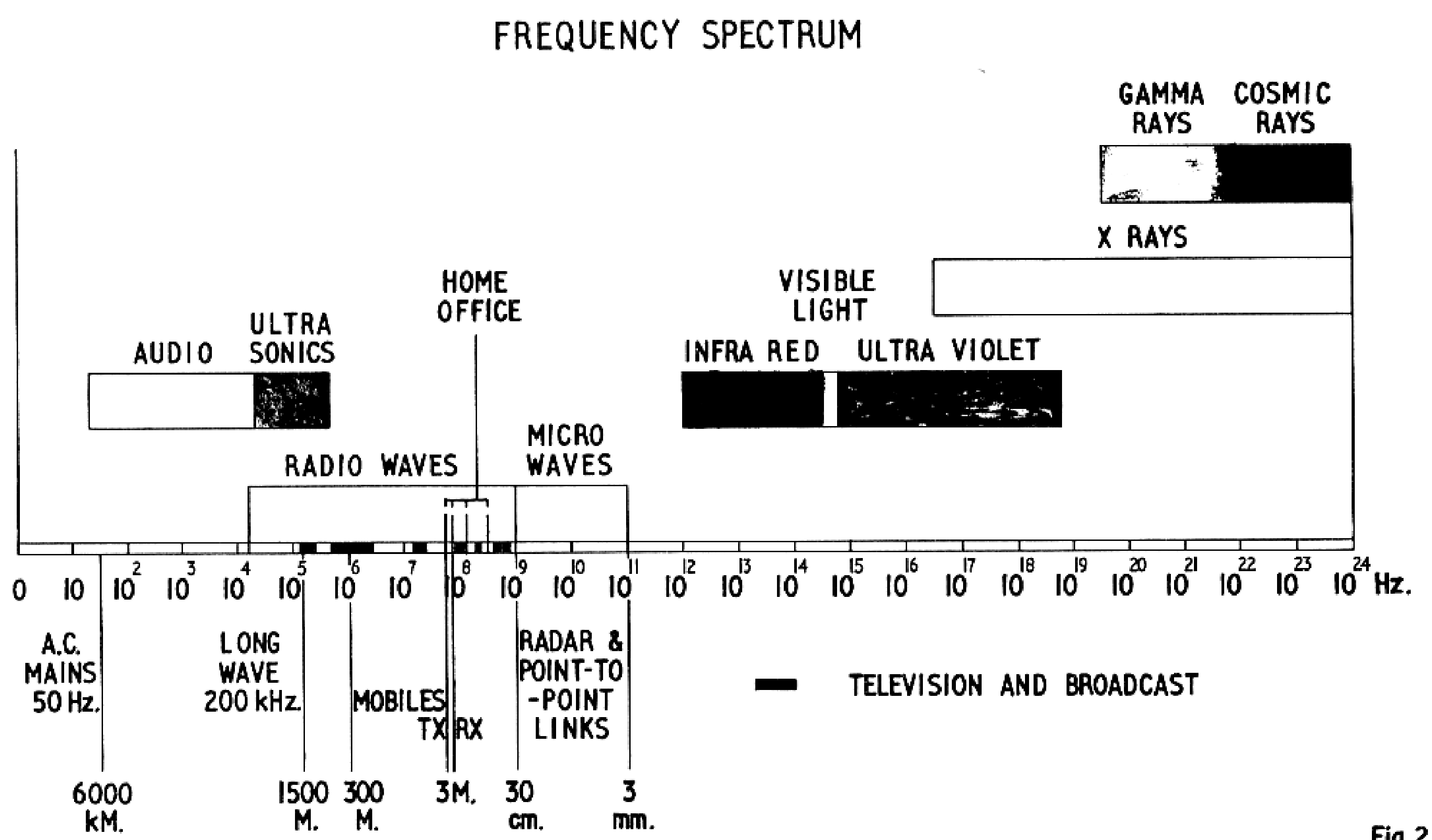
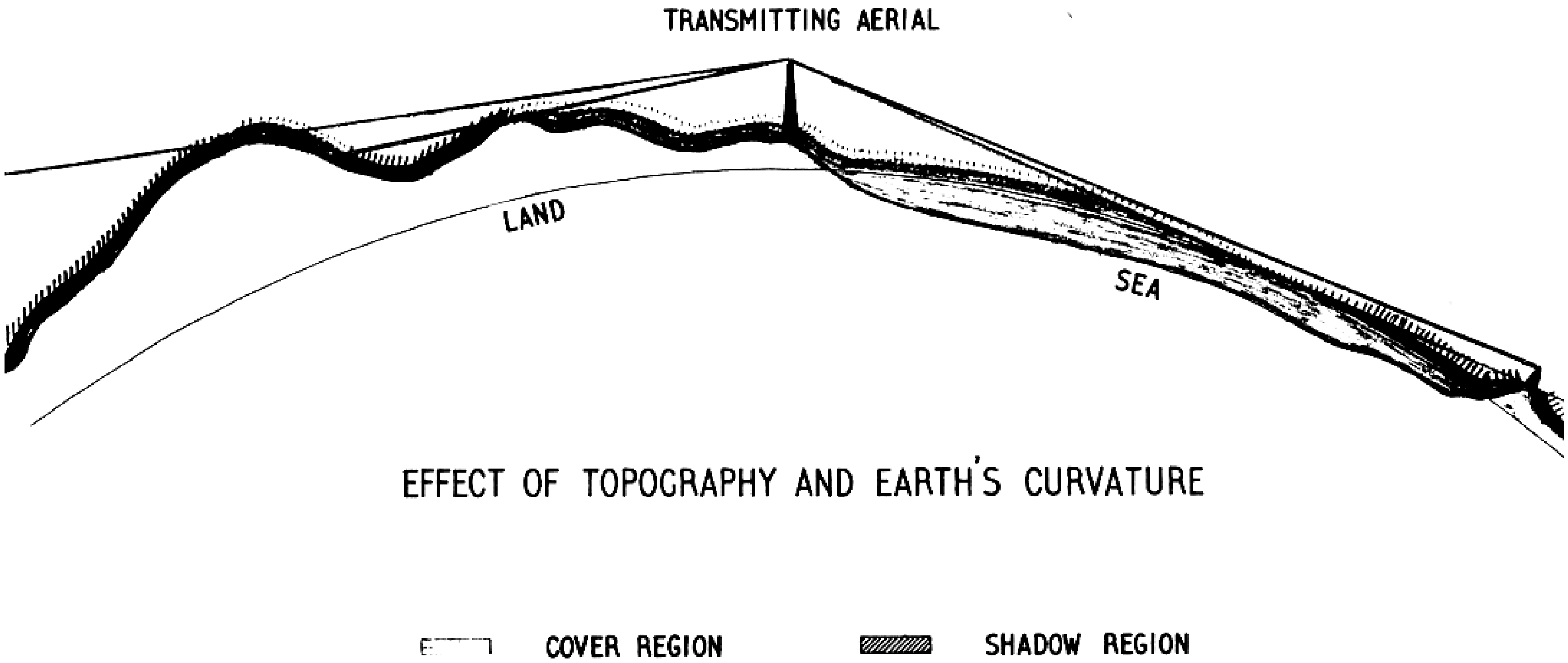

FREQUENCY SPECTRUM
GAMMA RAYS
COSMIC RAYS
X RAYS
VISIBLE LIGHT
INFRA RED
ULTRA VIOLET
HOME OFFICE
AUDIO
ULTRA SONICS
RADIO WAVES
MICRO WAVES
0
10
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
10^10
10^11
10^12
10^13
10^14
10^15
10^16
10^17
10^18
10^19
10^20
10^21
10^22
10^23
10^24 Hz.
A.C. MAINS 50 Hz.
LONG WAVE 200 kHz.
MOBILES
TX
RX
RADAR & POINT-TO -POINT LINKS
TELEVISION AND BROADCAST
6000 kM.
1500 M.
300 M.
3M.
30 cm.
3 mm.

Fig.2



EFFECT OF TOPOGRAPHY AND EARTH'S CURVATURE

Fig.3

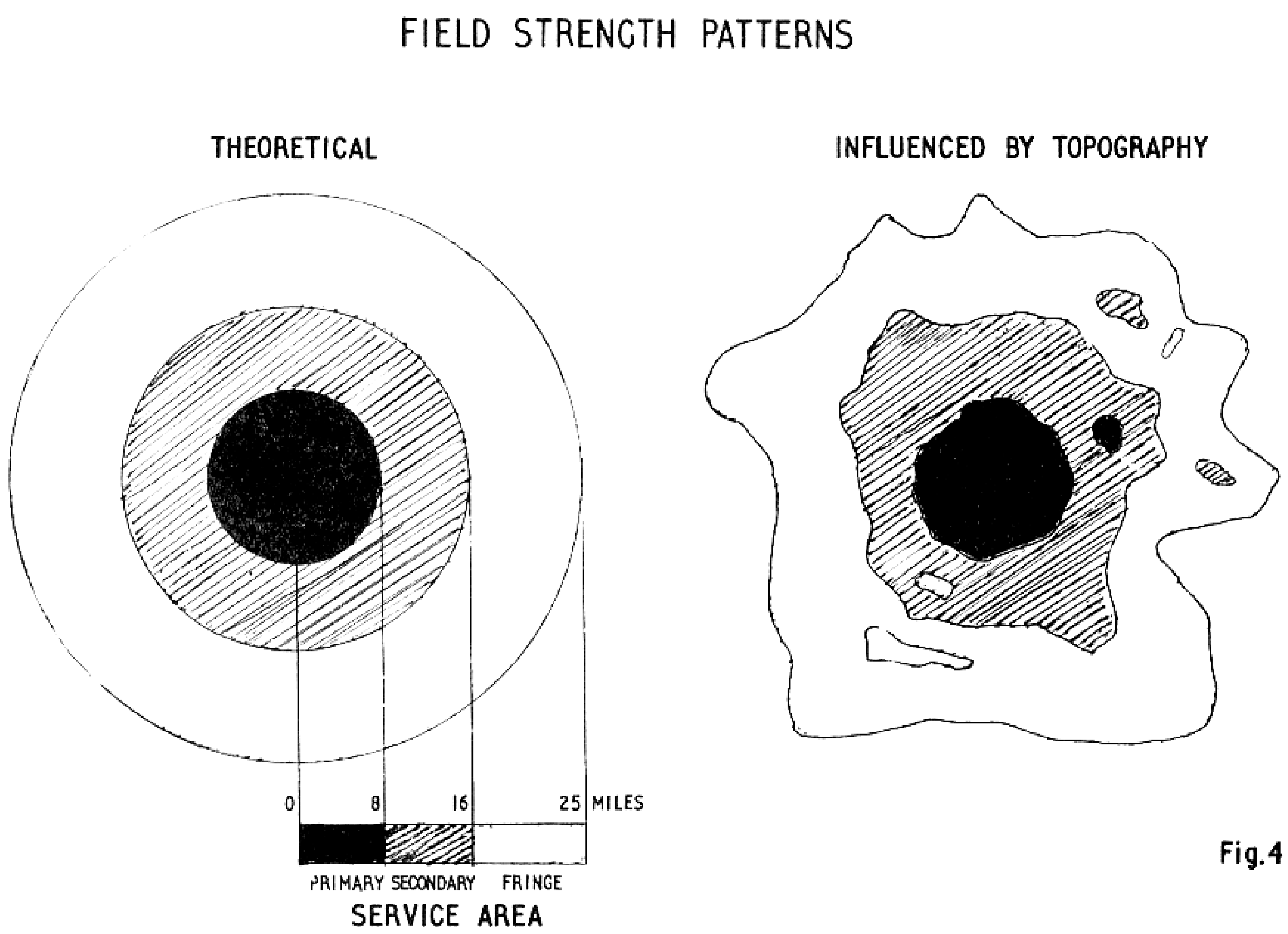

FIELD STRENGTH PATTERNS
THEORETICAL
INFLUENCED BY TOPOGRAPHY
0
8
16
25 MILES
PRIMARY SECONDARY FRINGE
SERVICE AREA

Fig.4

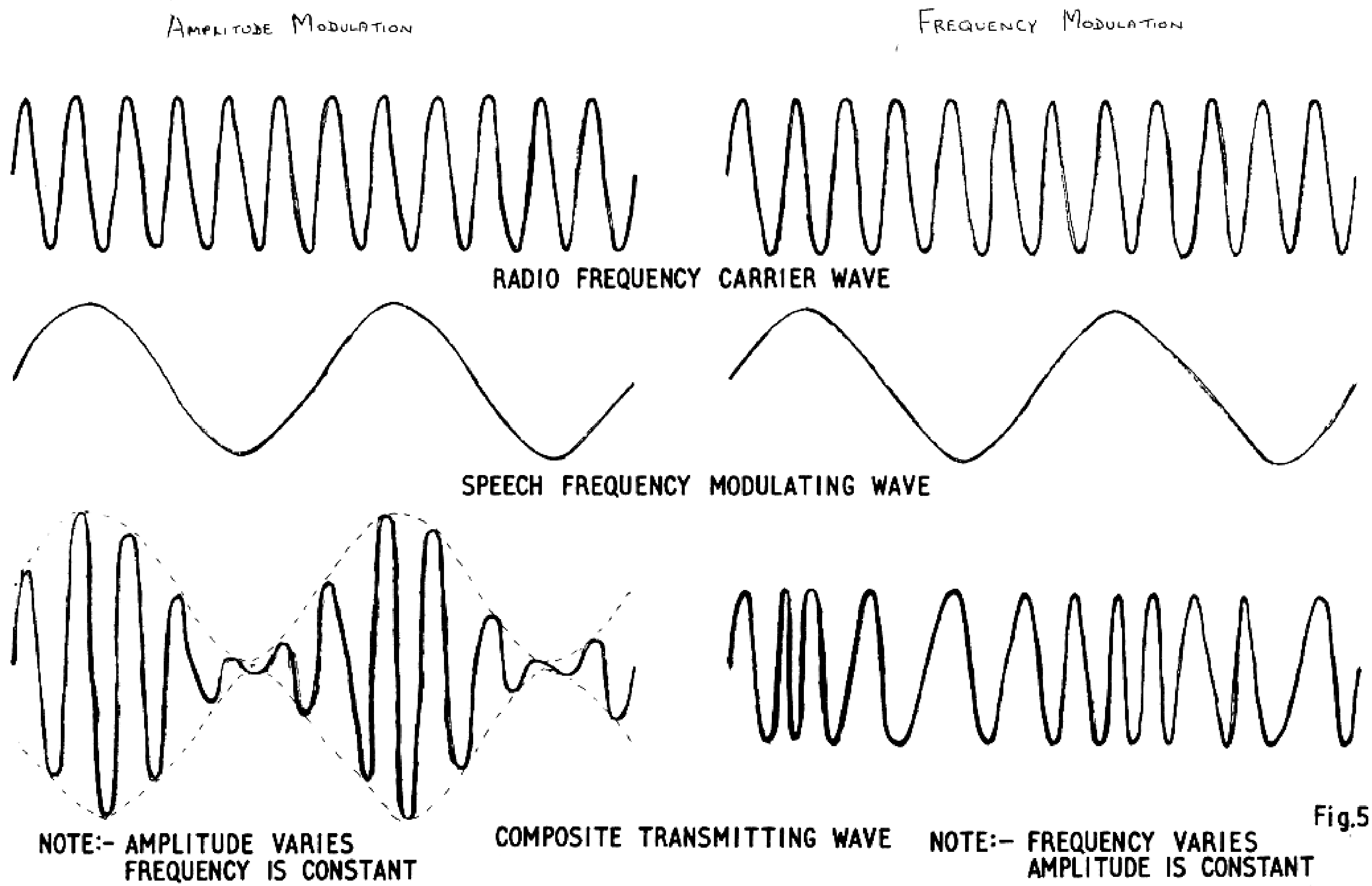

Amplitude Modulation
Frequency Modulation
RADIO FREQUENCY CARRIER WAVE
SPEECH FREQUENCY MODULATING WAVE
NOTE:- AMPLITUDE VARIES
FREQUENCY IS CONSTANT
COMPOSITE TRANSMITTING WAVE
NOTE:- FREQUENCY VARIES
AMPLITUDE IS CONSTANT

Fig.5

ARRANGEMENT OF CARRIERS IN 3 STATION SCHEME

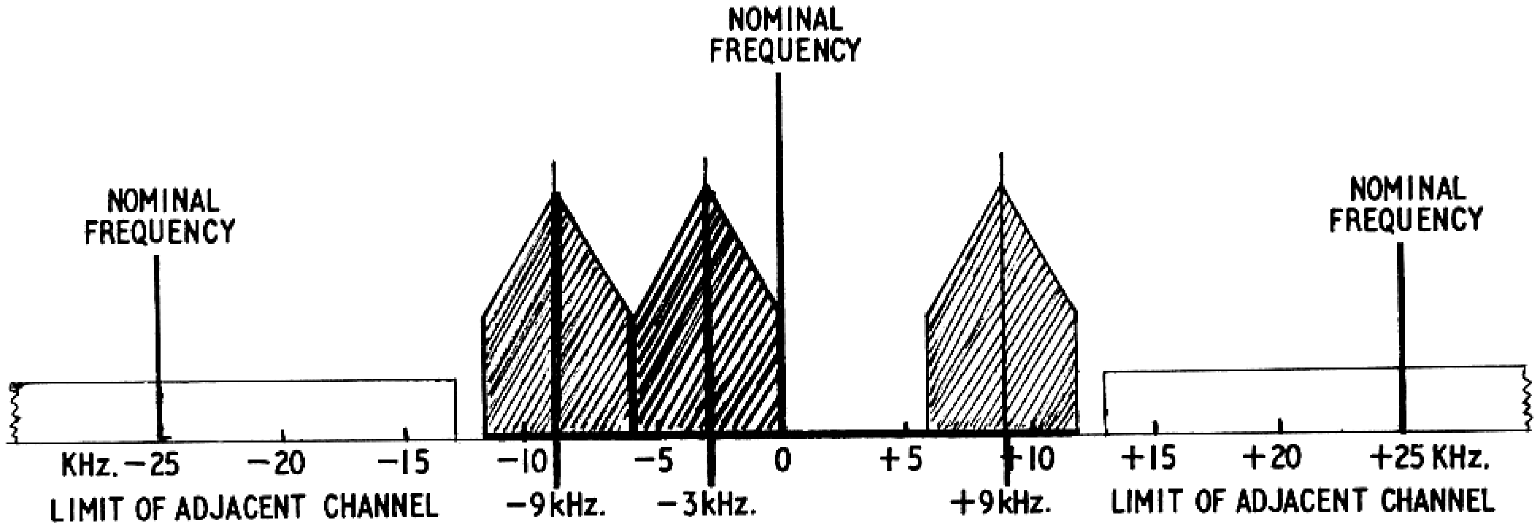


Fig.6

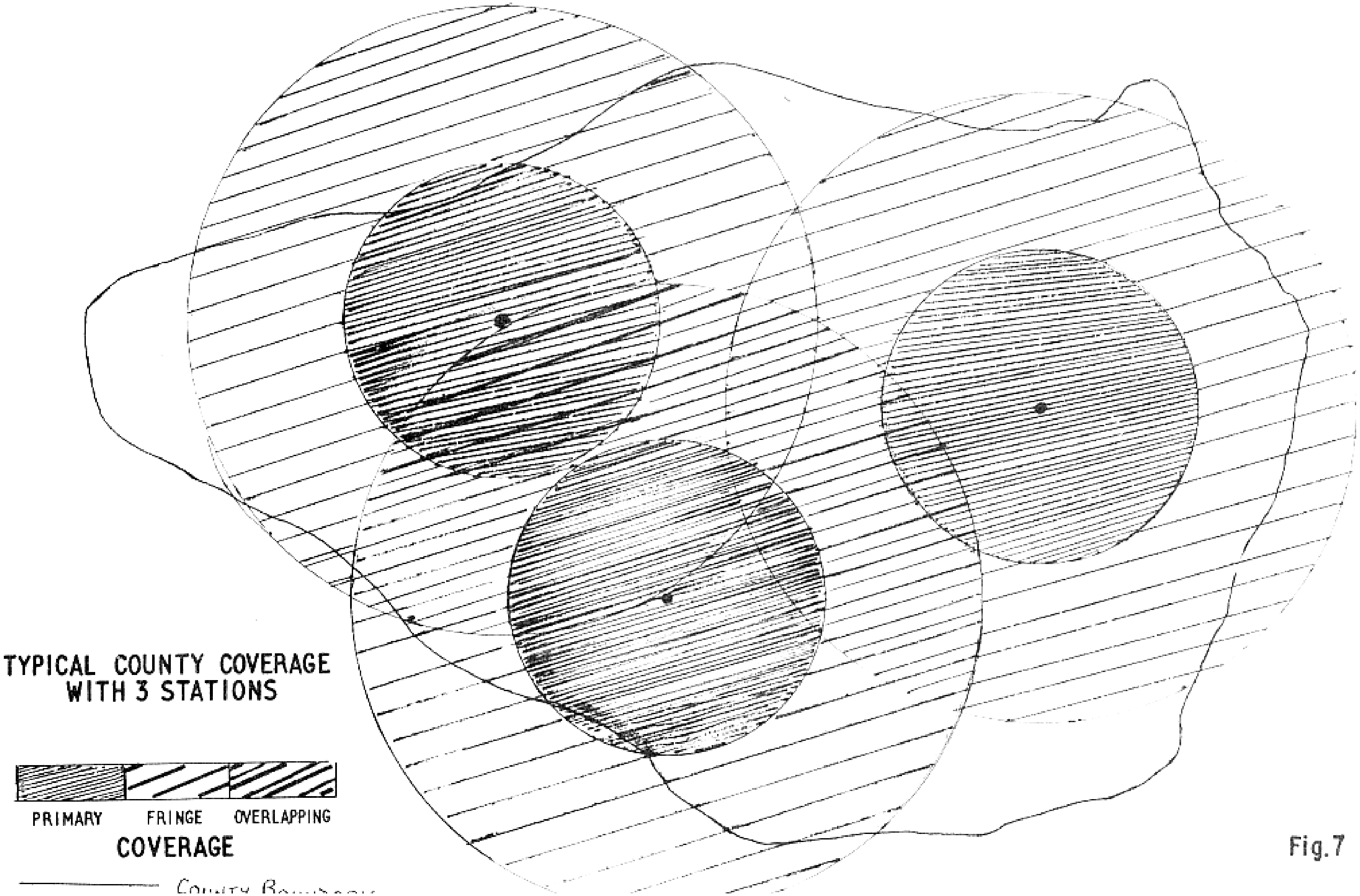
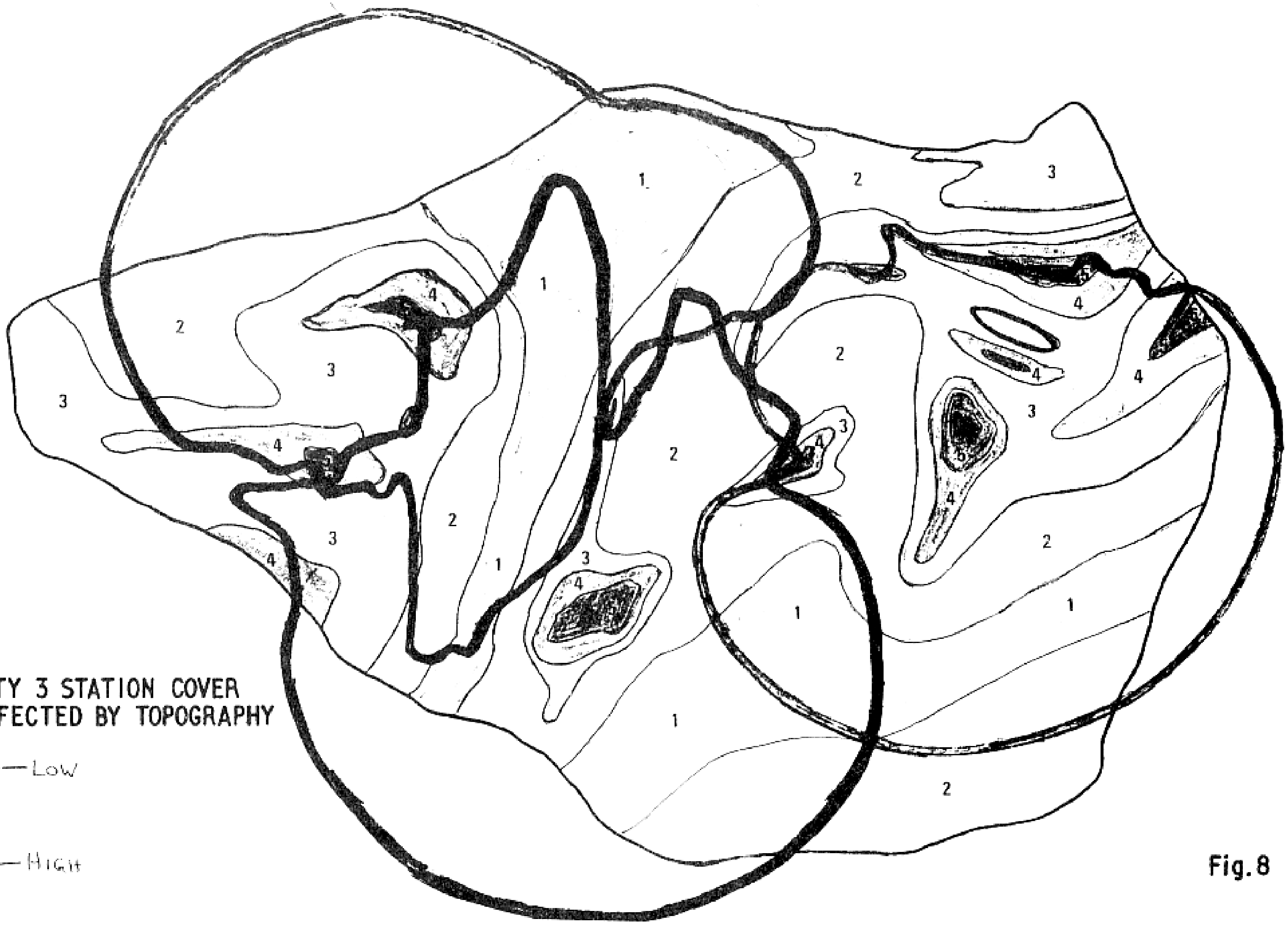

TYPICAL COUNTY COVERAGE
WITH 3 STATIONS
PRIMARY
FRINGE
OVERLAPPING
COVERAGE
County

Fig.7



COUNTY 3 STATION COVER
WHEN AFFECTED BY TOPOGRAPHY

Fig.8

H.O. FREQUENCY ALLOCATIONS

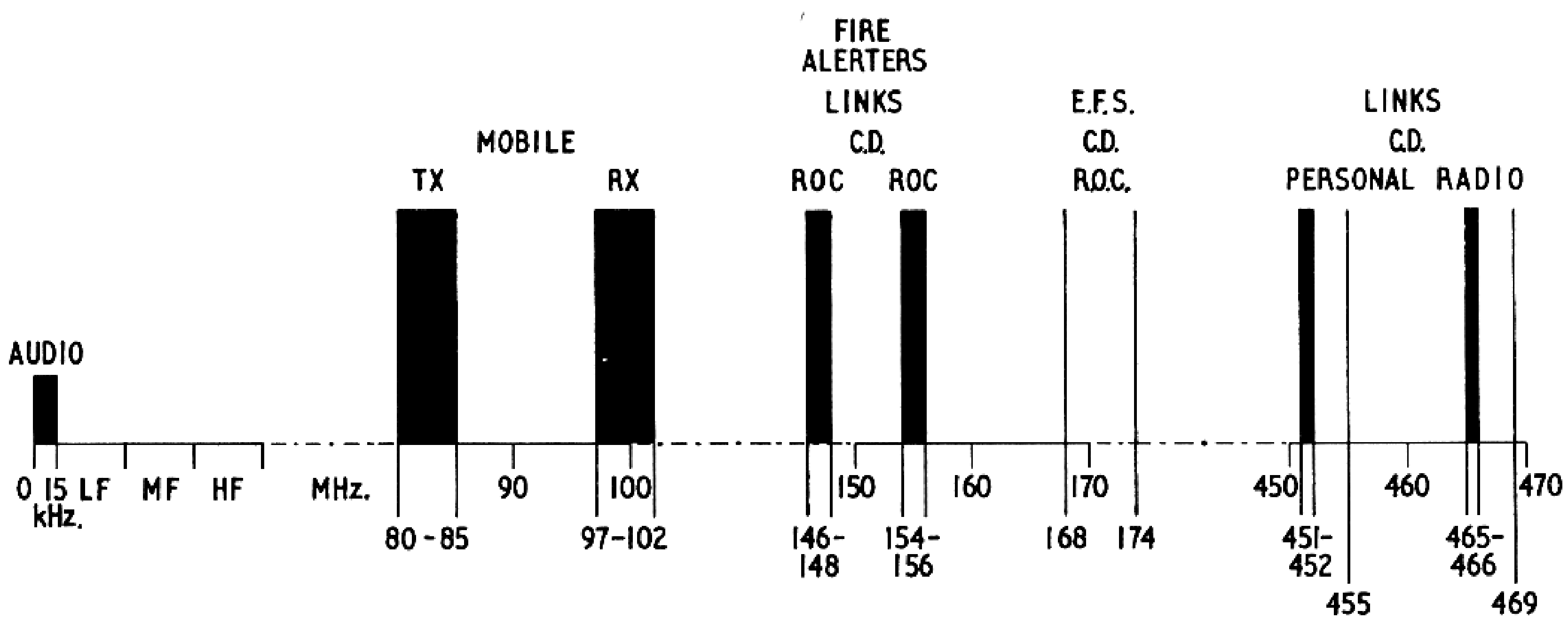
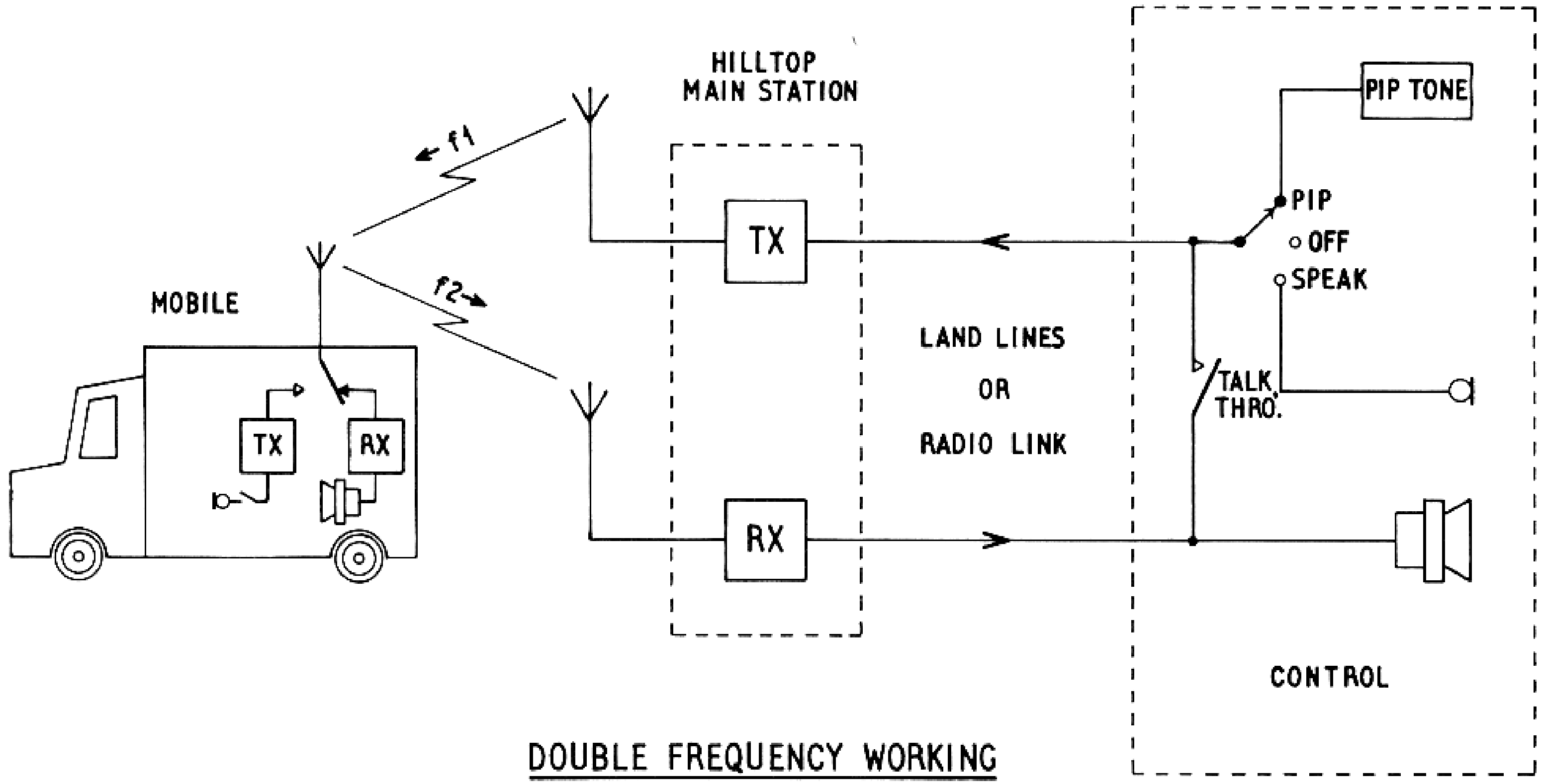
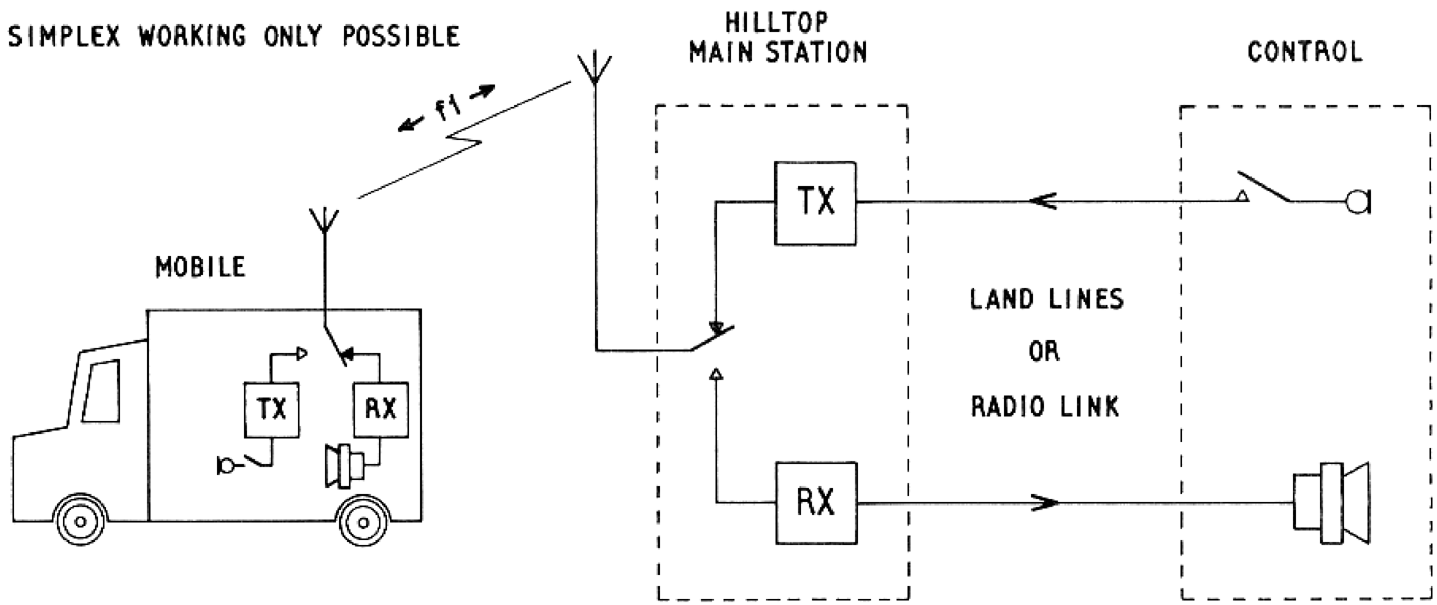


Fig.9



DOUBLE FREQUENCY WORKING
SIMPLEX

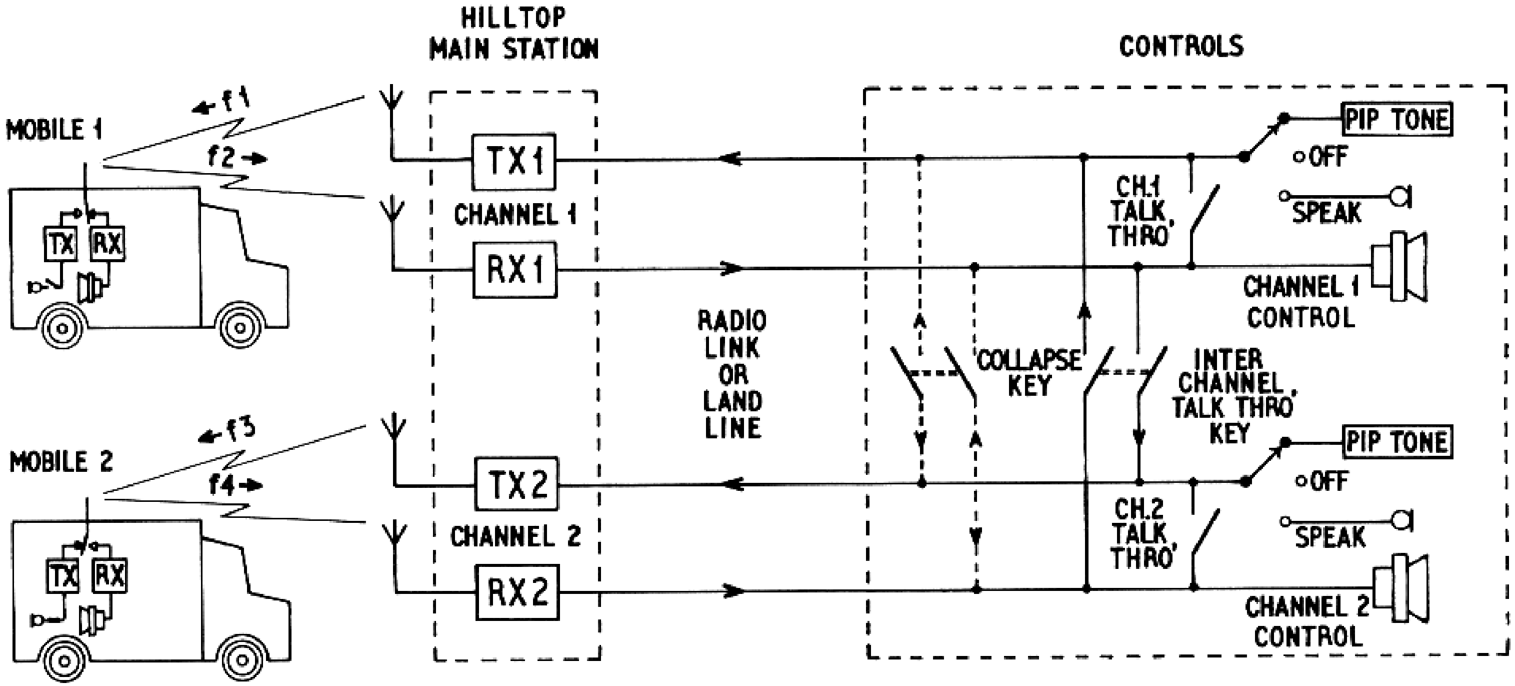
Fig.10



SINGLE FREQUENCY WORKING

MOST ELEMENTARY SYSTEM POSSIBLE

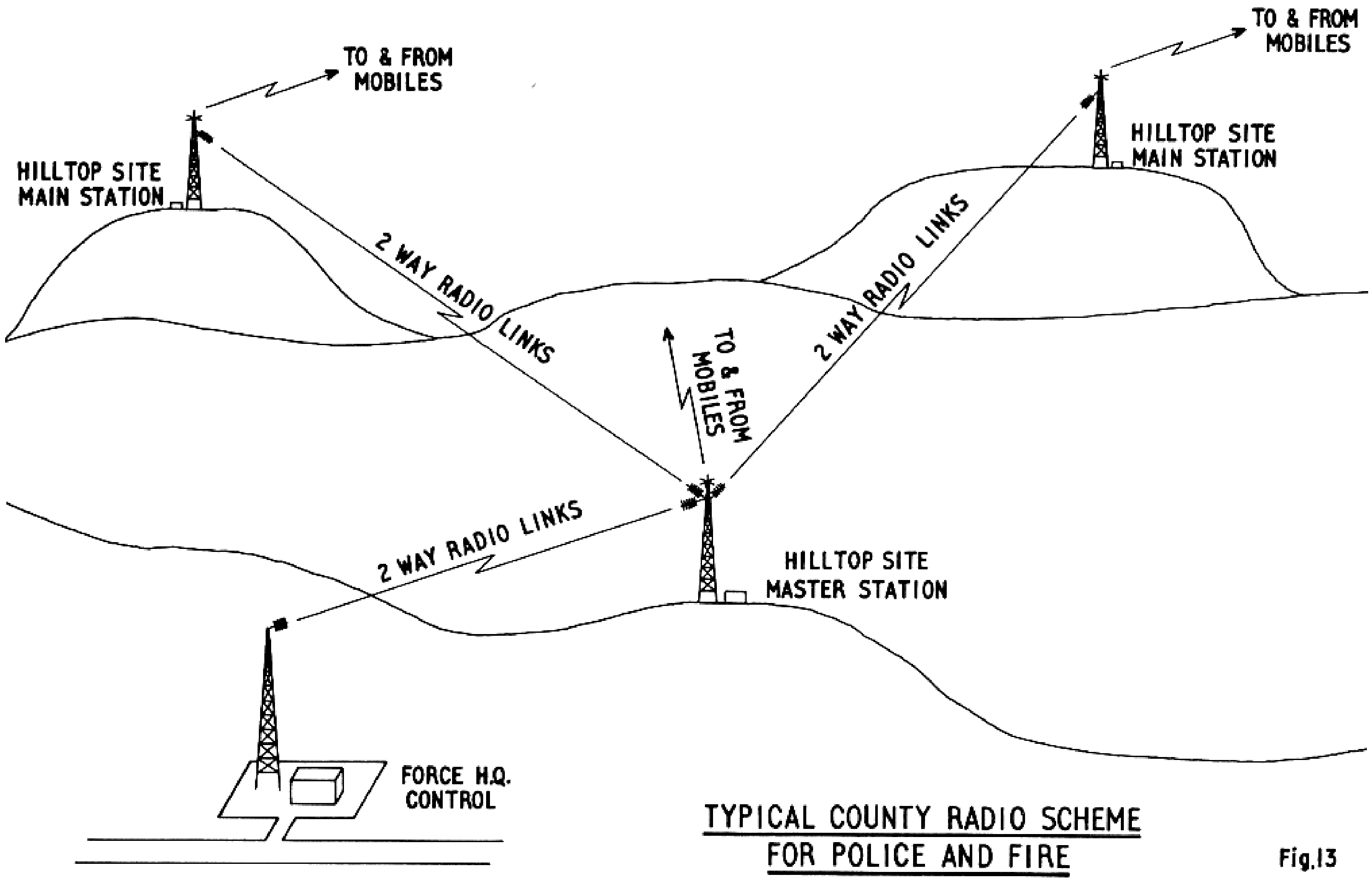
Fig.11



INTER CHANNEL TALK THROUGH

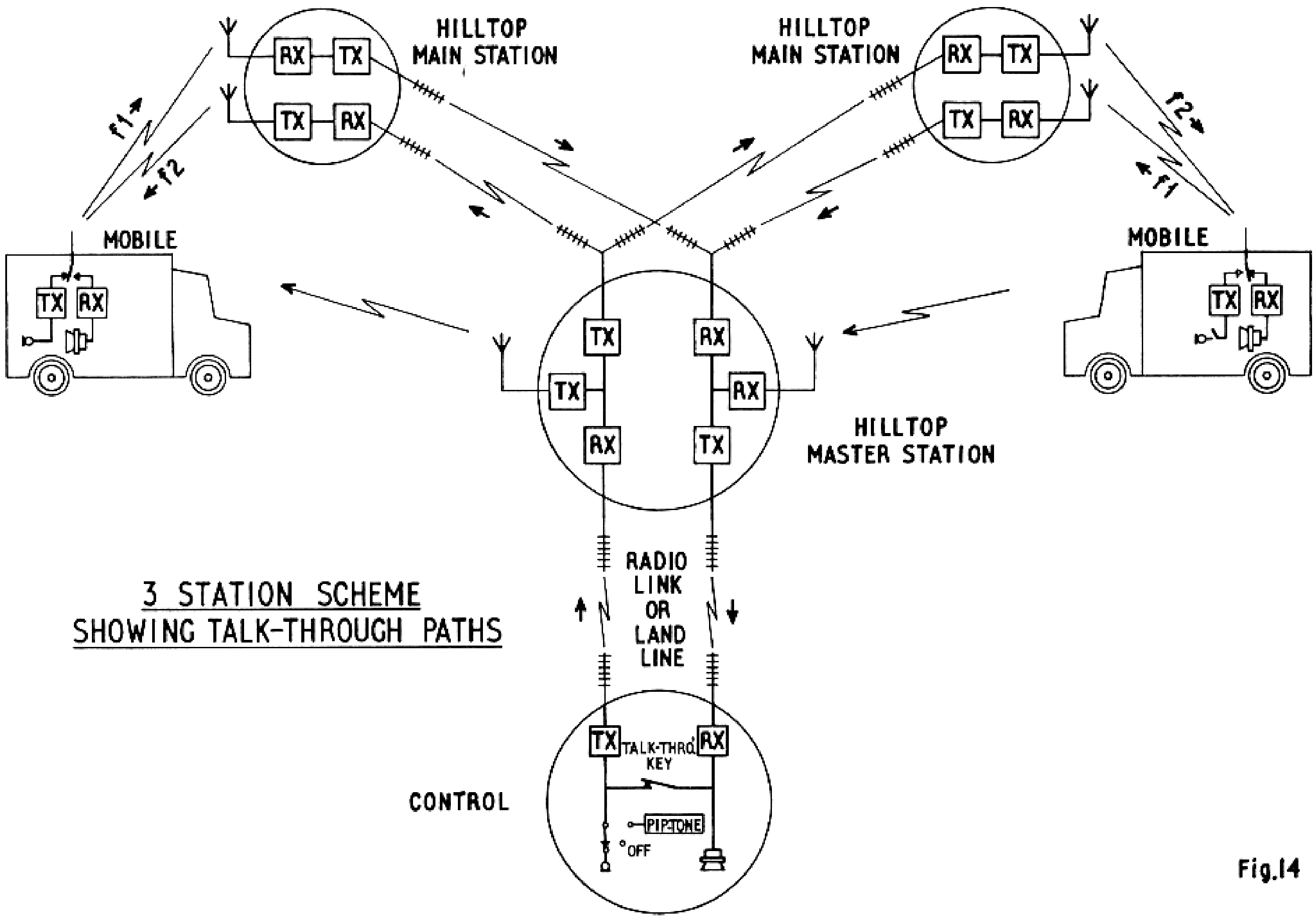
WITH OWN CHANNEL TALK THROUGH & COLLAPSE FACILITIES

Fig.12



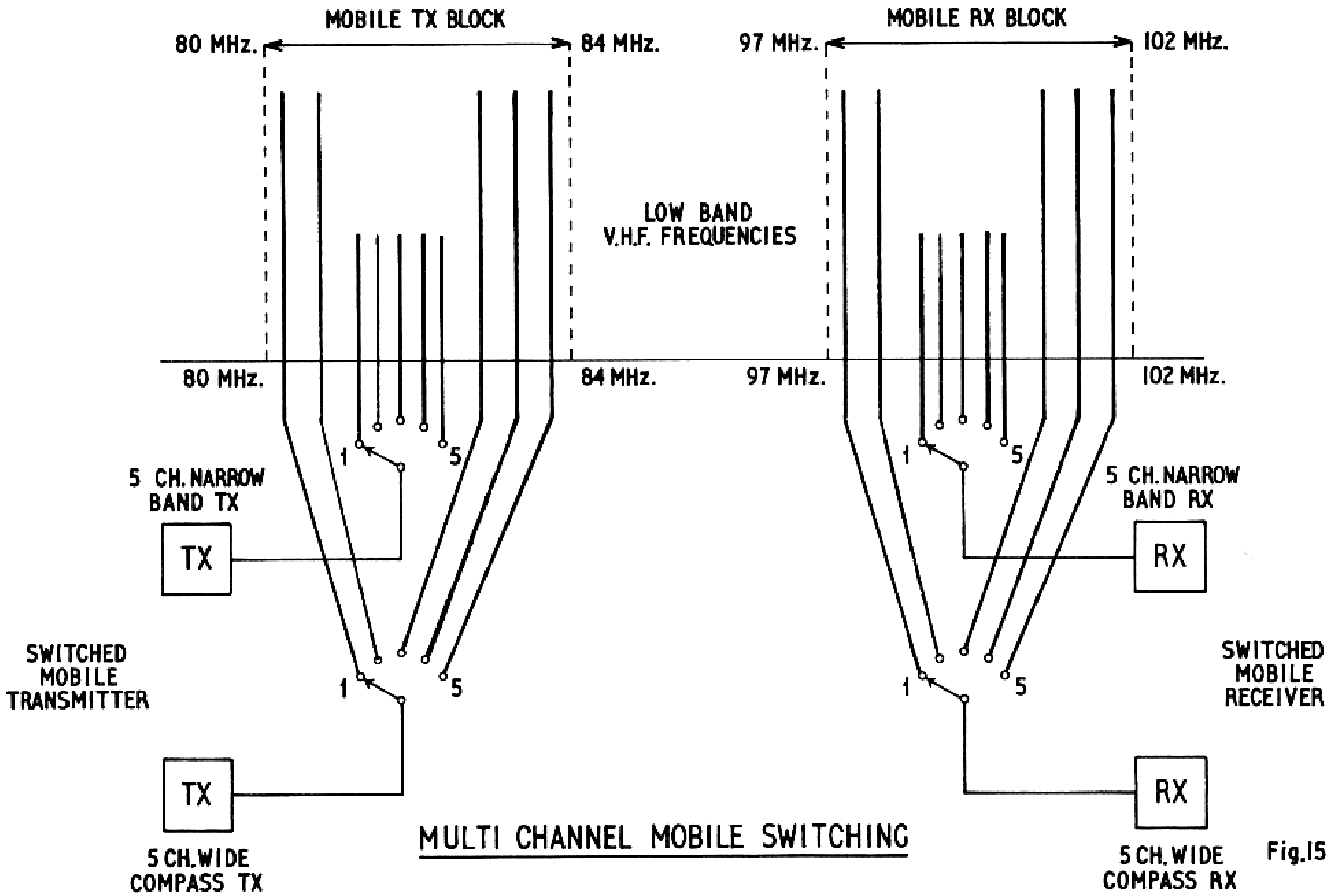
TYPICAL COUNTY RADIO SCHEME
FOR POLICE AND FIRE

Fig.13



3 STATION SCHEME
SHOWING TALK-THROUGH PATHS

Fig.14



MULTI CHANNEL MOBILE SWITCHING

Fig.15

DIAGRAM "A"
Showing how the "AF 101" Set is Installed in Column Control Unit

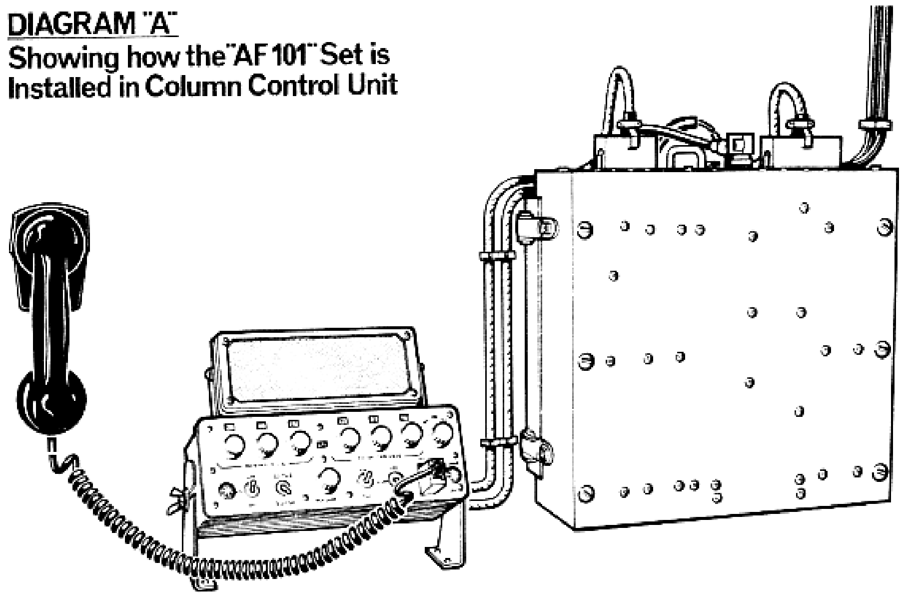


DIAGRAM "B"
Control Box of the "AF 101" Tunable Mobile Radio Set

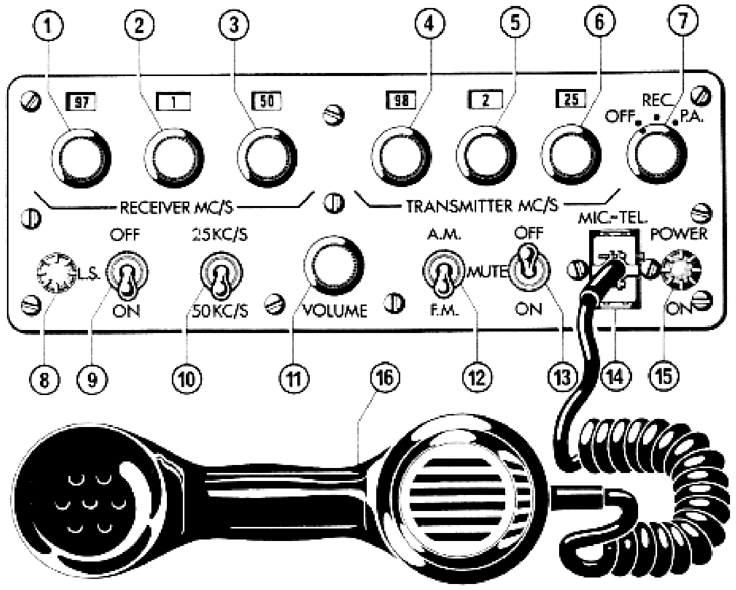
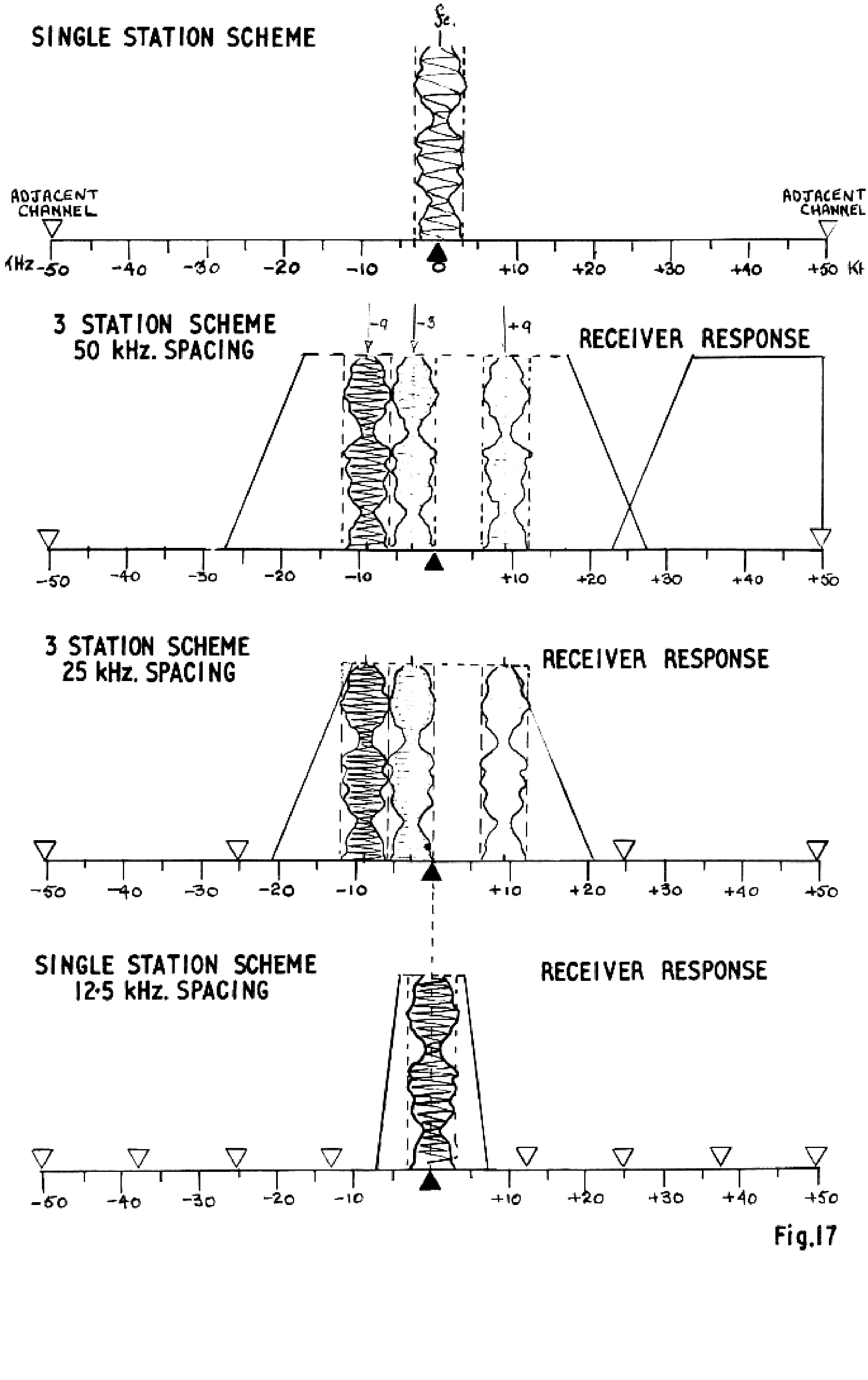
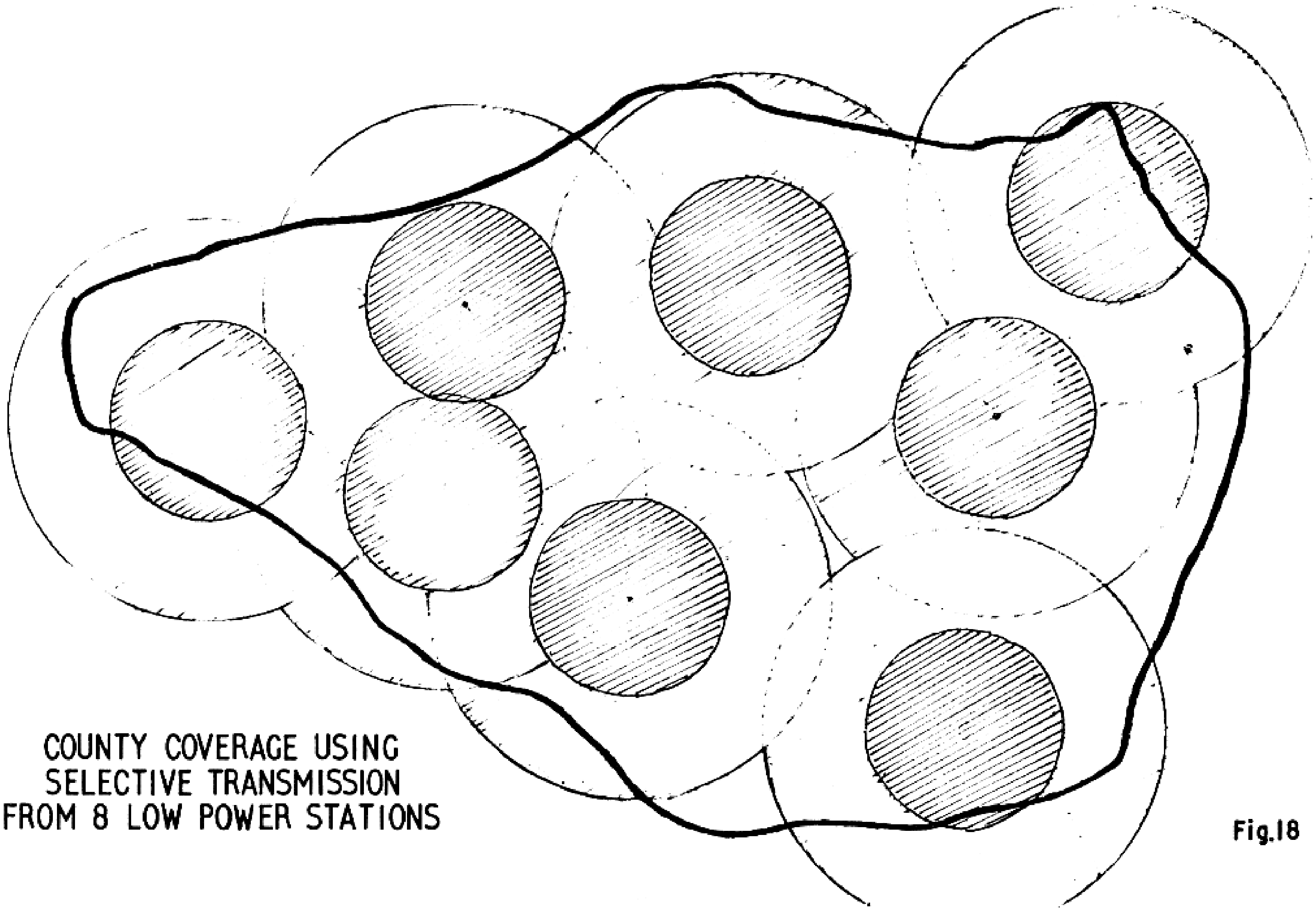


Fig. 16



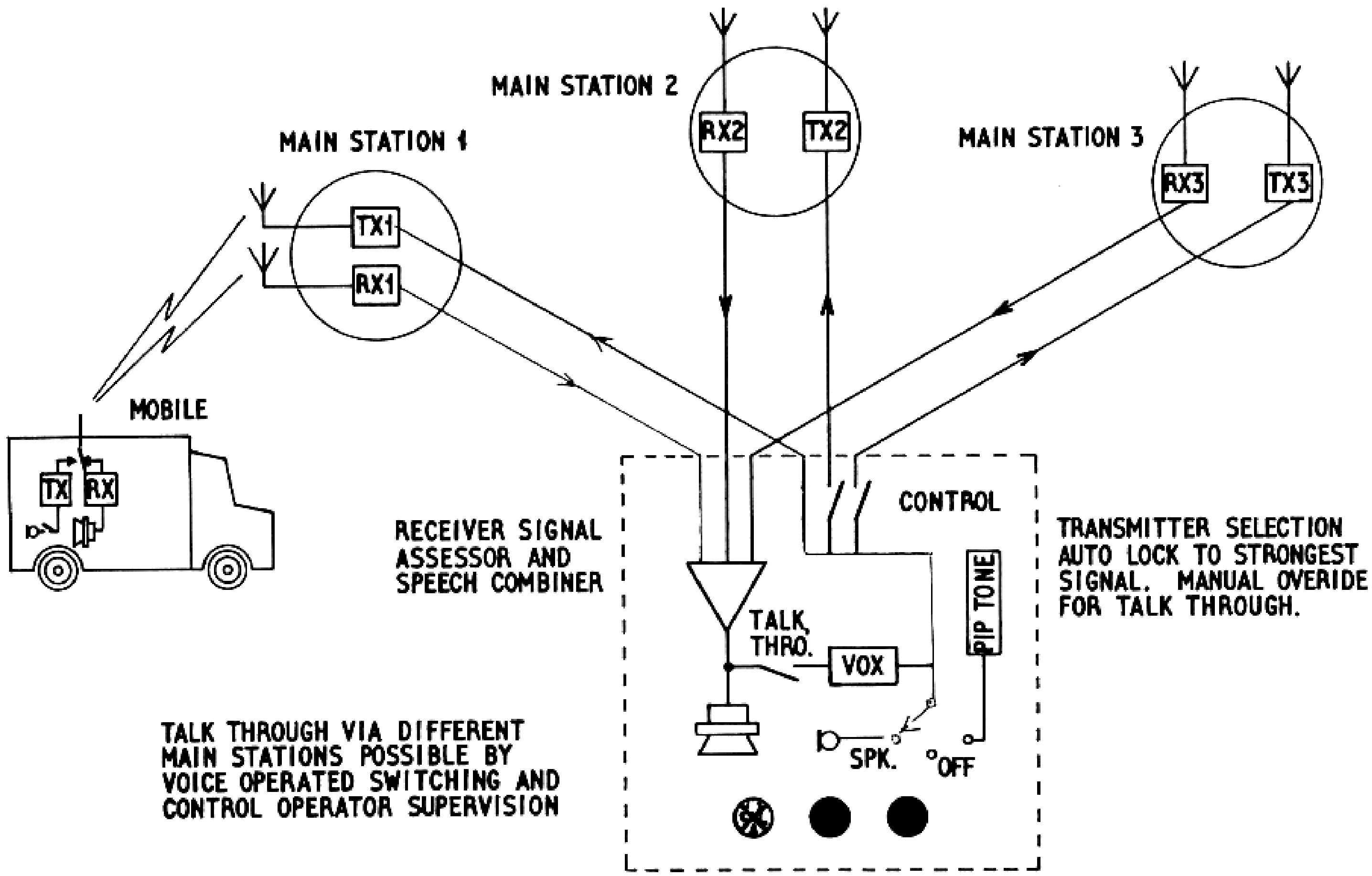
SINGLE STATION SCHEME
fc.
ADJACENT CHANNEL
ADJACENT CHANNEL
-50
-40
-30
-20
-10
0
+10
+20
+30
+40
+50
3 STATION SCHEME
50 kHz. SPACING
-9
-3
+9
RECEIVER RESPONSE
3 STATION SCHEME
25 kHz. SPACING
RECEIVER RESPONSE
SINGLE STATION SCHEME
12·5 kHz. SPACING
RECEIVER RESPONSE

Fig.17



COUNTY COVERAGE USING
SELECTIVE TRANSMISSION
FROM 8 LOW POWER STATIONS

Fig.18



ONE TYPE OF RECEIVER SELECT SYSTEM

Fig.19