## A survey of radio communications for the Department of Northern Affairs and National Resources

Pattenson, C.F.


*Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERB), 1963-05*

ERB-633

UNCLASSIFIED

NATIONAL RESEARCH COUNCIL OF CANADA
RADIO AND ELECTRICAL ENGINEERING DIVISION



# A SURVEY OF RADIO COMMUNICATIONS FOR THE DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

C. F. PATTENSON

OTTAWA
MAY 1963

## CONTENTS



## FIGURES

## FIGURES

# A SURVEY OF RADIO COMMUNICATIONS FOR THE DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

- C.F. Pattenson -

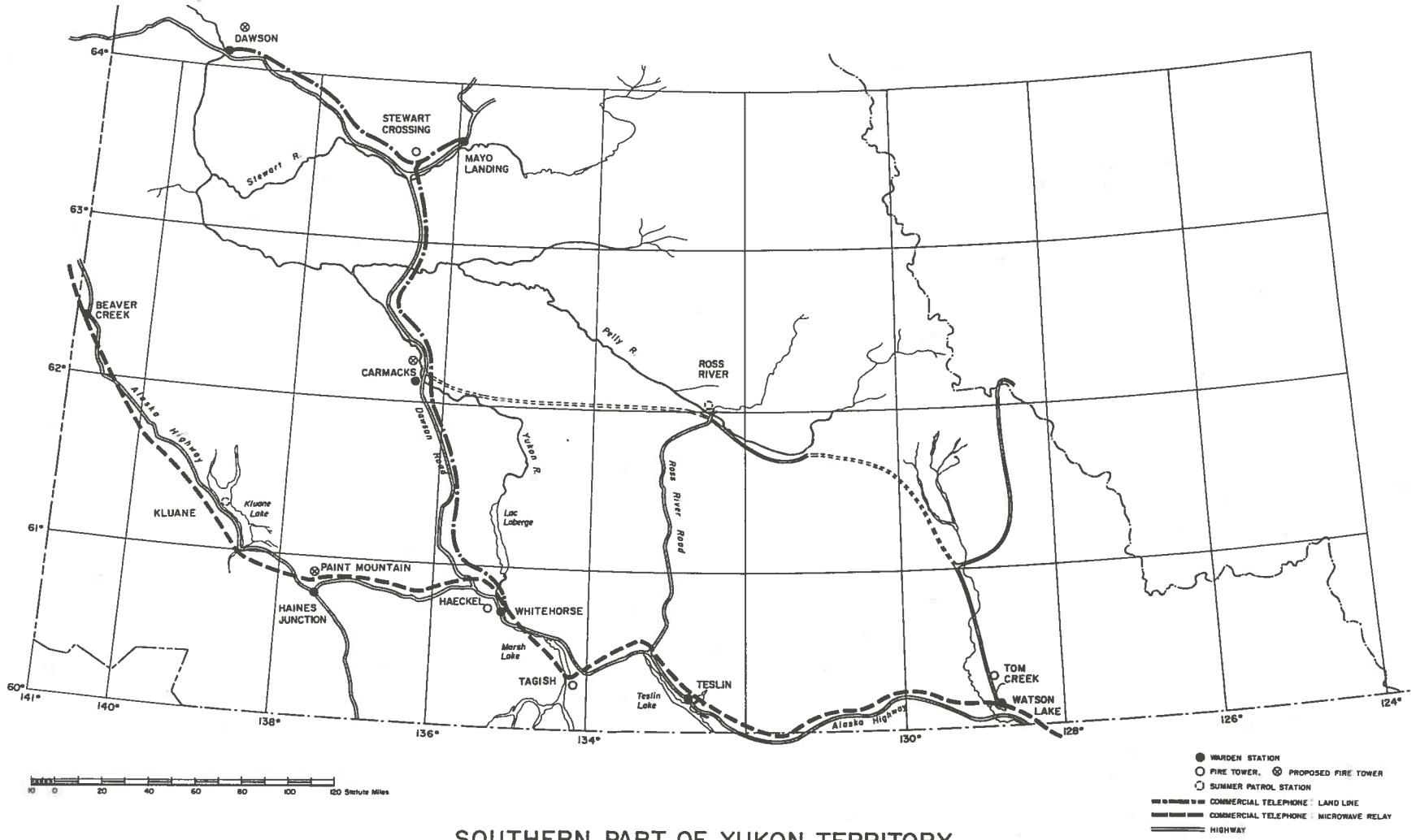
## INTRODUCTION

In this report an inspection and study of existing radiotelephone systems of the forestry sections of the Department of Northern Affairs and National Resources in the Yukon Territory and the MacKenzie District of the Northwest Territories is discussed. The survey was requested because of the failure of radio communications in the MacKenzie District, which was experienced during the summer of 1961 and which occurred during a particularly bad forest-fire period. Factors, such as kind of service, service range, propagation of radio signals, radio equipment and antennas, operational requirements, and equipment maintenance are considered. The present systems are assessed and recommendations are made, taking into account alternative means of communication, for operation over the coming five years. Appendices are attached which describe the operation of the two systems and condition of equipment as of July 1962, and which give detailed recommendations regarding station installations.

The Yukon Territory and the MacKenzie District each has its own forest protection and management organization. In the Yukon the forestry section is a separate group with its own personnel and equipment. In the MacKenzie District the warden stations are all primarily game management posts, with the forestry official attached to the same post on a summer seasonal basis. Radio equipment is held and operated by both forest and game sections although, because of circumstances, the forestry section has been largely responsible for the installation and operation of the system. The situation in the Mackenzie District is further complicated by the fact that other Divisions of the Department, such as Education, Engineering, etc., also possess radio equipment and operate into the radio system. In both districts a certain number of survey parties, and commercial operations, such as sawmills and mines, work into the radio systems, but this is by prearrangement and no difficulty is encountered.

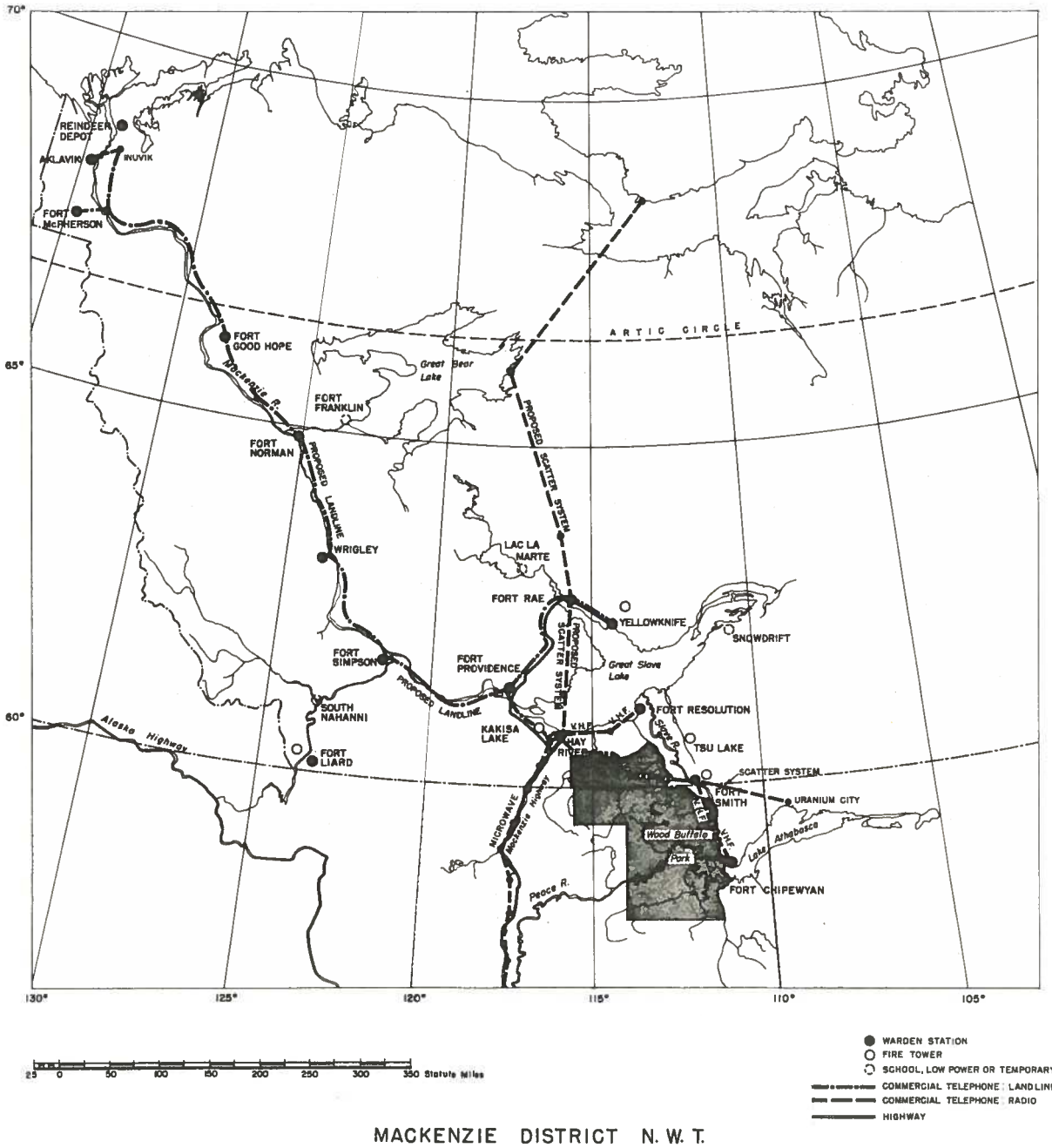
In both districts one is concerned with large areas. In the Yukon, at the present time, the area is that bounded by the MacKenzie boundary on the east, British Columbia on the south, Alaska on the west, and the 65th parallel on the north (Fig. 1). The main areas of operation approximate the routes of the Alaska and Dawson City highways, and the Ross River Road, and warden stations are located on them.

The MacKenzie forestry district is larger than the Yukon, and encompasses the area from 102° W to the Yukon border and from 60° N to the Arctic Coast (Fig. 2),




SOUTHERN PART OF YUKON TERRITORY
SHOWING
FOREST SERVICE RADIO STATIONS

Fig. 1




MACKENZIE DISTRICT N. W. T.

SHOWING

FOREST SERVICE RADIO STATIONS

Fig. 2

with Wood Buffalo Park to the south (Fig. 3). However, activity is limited to the area defined roughly by the northern limit of trees, and is mainly in the area west of the eastern end of Great Slave Lake and extending up the MacKenzie River to the coast.

At the present time facilities for communications in the Yukon are good (Fig. 1). All warden stations can be reached by all-weather roads, and since the recent installation of the CNT microwave and land-line facilities along the Alaska and Dawson City highways, all are connected by long-distance dial telephone. The situation in the MacKenzie District is quite different. Radio is the only means of communication over a large part of the district, although along the southern border land-line telephone is available. Hay River, Yellowknife, and Fort Smith, together with intermediate points on the highway, are connected by road, long-distance telephone, or both; long-distance telephone is available between Fort Smith and Fort Chipewyan via the Alberta Government Telephones' VHF radio relay (Fig. 2). There are proposals for road and telephone communications extending down the MacKenzie to Inuvik [1].

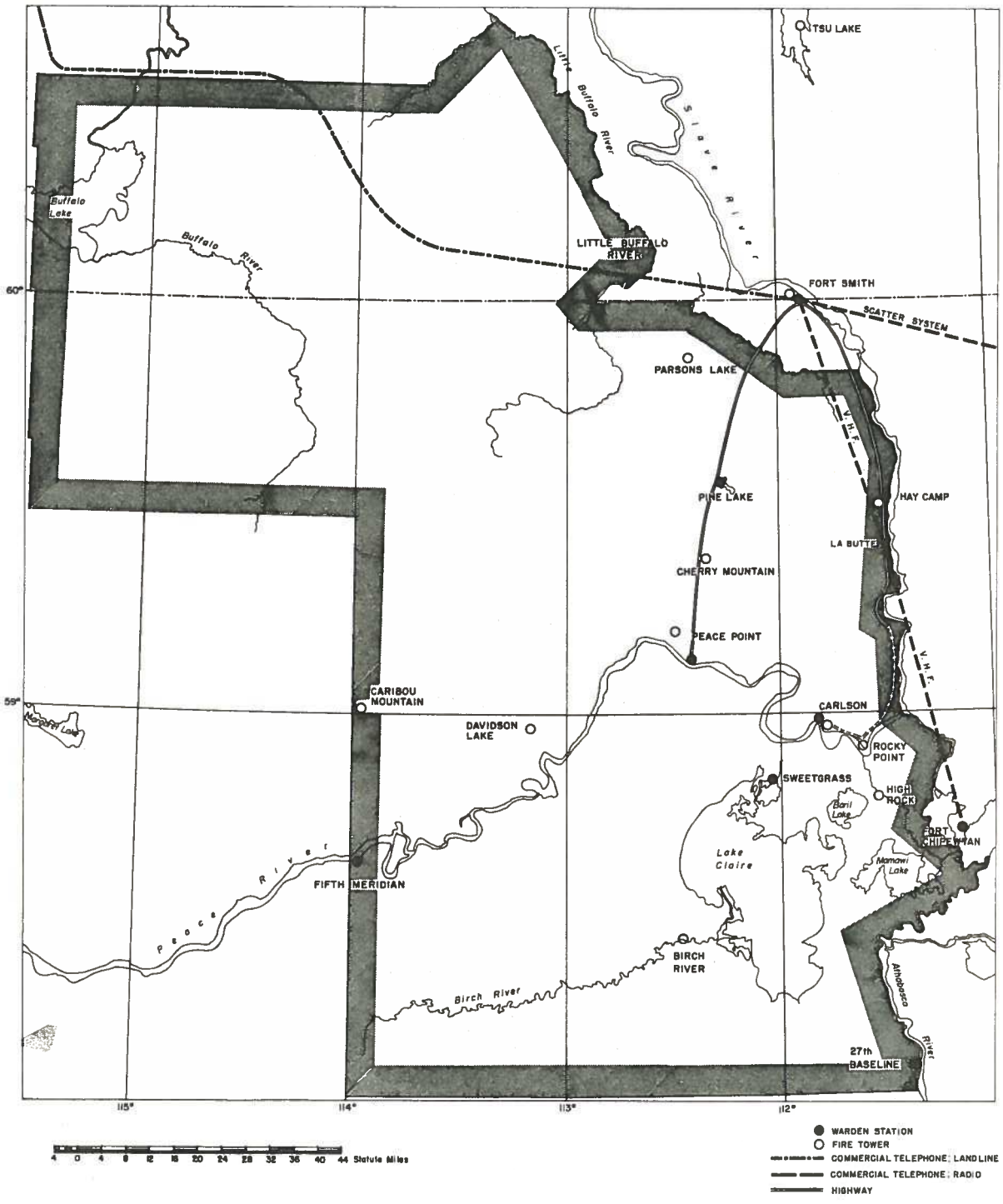
## RADIO-FREQUENCY PROPAGATION

Because some appreciation of the way radio signals are transmitted is useful, a brief review of the mechanism of radio propagation is desirable at this point.

Two regions in the radio-frequency spectrum are suitable for a communication service of the kind under discussion. First is the high-frequency region which spans the frequency range from 1.5 mc/s to 30 mc/s; second is the very-high-frequency region from 30 mc/s to 1000 mc/s.

In high-frequency (HF) radio communication sky-wave signal (reflection of the signal from the ionosphere) is used, and communication over long distances is accomplished with relatively low-power, simple, and inexpensive transmitters, receivers, and antenna systems. However, since the signal is propagated by refraction and reflection from the ionosphere, system reliability is critically dependent on the state of ionization of the ionosphere, which, in turn, is directly influenced by daily, seasonal, long-term and sporadic changes in radiation from the sun.

The state of the ionosphere determines the choice of frequency, kind of antenna, and transmitter power used for communication over a given path. Because of the manner in which the radio-frequency energy of the signal interacts with the ionized particles of the ionosphere, and because of the geometry of the radio path, there is a maximum frequency which can be used for a particular path. At the same time, there is a lower frequency limit below which signals are absorbed in the ionosphere. Common practice is to choose a frequency as close as possible to the maximum




WOOD BUFFALO PARK

SHOWING

FOREST SERVICE RADIO STATIONS

**Fig. 3**

usable frequency in order to avoid absorption loss. This frequency is usually 85% of the maximum usable frequency. Because of diurnal changes in the ionization of the ionosphere, different frequencies are needed for day and night communication in order to ensure maximum reliability. These must be changed from summer to winter, and during the 11-year sunspot cycle. Because of congestion of the radio spectrum and economic factors, it is impossible to adopt an ideal set of frequencies. A compromise must be made, and in practice the minimum number of frequencies sufficient to achieve the desired reliability is used.

Sporadic changes in the state of the ionosphere may change its reflecting and absorbing characteristics to the extent that complete communication blackouts will occur, which may last from a few minutes to several days. The effect of these disturbances is most pronounced in the auroral zones which are several hundreds of miles wide, centered on the magnetic poles. Since the Territories lie within the northern auroral zone, these factors have great bearing on the operation of radio systems in these areas.

Transmitting and receiving antennas are chosen so that the maximum energy is radiated in a horizontal direction and at a vertical angle which are both determined by the geometry of the communication path. In general, the shorter the path, the higher the vertical angle of radiation. Transmitter power is determined by the strength required of the received signal to exceed atmospheric and electrical noise and to compensate for loss of signal intensity in traveling from the transmitter to the receiver. Atmospheric noise tends to increase with the degree of ionospheric disturbance, and because of the very fact that communication can be achieved over long distances with small transmitter power, distant stations can also be a source of interference, especially during the night hours.

To sum up, HF communication is excellent for long-distance communication with low power; it is widely used for transoceanic communication, and in many areas it is the only practical method. However, because of the nature of radio wave propagation, a high order of system reliability cannot be achieved with HF. In addition, the problems of interference from other stations, atmospheric noise, and man-made noise can be severe. A further disadvantage in HF radio communication for mobile stations mounted in vehicles is that efficient antenna systems cannot be used.

The chief feature of very-high-frequency (VHF) communication is that the frequency of the radiated energy is such that, to a first-order, the energy is unaffected by the presence of the ionosphere. Communication is by the so-called "direct ray", and since the radiated energy behaves in a manner analogous with optical energy, communication is limited to distances only slightly greater than optical line of sight. If communication is required over greater distance, repeater stations must be used to receive, amplify, and re-transmit the signal to the

next station. However, since the signal is largely unaffected by the condition of the propagation medium (the lower atmosphere), signal levels, once established between fixed stations, are extremely reliable. Since the range of a VHF station is limited to line of sight, this range is, of course, directly related to the height of the receiving antenna. Thus, on flat terrain, relatively high and expensive antenna support structures are required to achieve communication to a reasonable distance. In hilly or mountainous country advantage can be taken of topographical features when siting to obtain maximum range. In many areas of the country suitable sites have already been developed by commercial communication interests, and it is usual for more than one service to share a particular site.

Since VHF equipment is more complex than HF equipment, it is somewhat more expensive, and a higher order of skill and experience is required of maintenance personnel. VHF antennas, however, are smaller and more efficient, and are more suitable for mobile and portable installations, and, in addition, mobile equipment requires a minimum of field adjustment.

In summary then, VHF propagation is more reliable than HF propagation. A VHF radio system is not as susceptible to interference and noise as an HF system. Because of the simplicity of operation and smaller size of the radio equipment and antennas, it is particularly suitable for mobile radio systems. On the other hand, service range is limited compared with that of HF, and the equipment is somewhat more expensive than the simpler types of HF equipment.

## MACKENZIE DISTRICT FORESTRY RADIO SYSTEM

In the MacKenzie District, where game and forestry management are combined, the radio communication system serves both functions. Radio communication was introduced during 1945-46 using war-surplus military HF equipment. By 1949, a 50-watt base station had been installed at Fort Smith and one or two 15-watt fixed stations at other locations; several 1- to 2-watt battery-operated portable sets were in use. During this period activity was confined to the area of Wood Buffalo Park, although some attempts were made to establish communication with Yellowknife and Resolution. During the 1950's more equipment was purchased and the system was gradually expanded until all the permanent posts in the District were equipped. Around 1957, responsibility for organization, maintenance, and operation of the radio system was assumed by the Forestry Section, and the system was built up to essentially its present state.

For administration of game and forestry the MacKenzie District is divided into ten management districts:

Aklavik/Inuvik
Fort McPherson

Fort Norman
Fort Liard
Fort Simpson
Hay River
Rae
Yellowknife
Fort Resolution
Fort Smith

and the radio system establishment which provides communication for these districts is as follows:

AKLAVIK — Inuvik: base station, two portables

FORT McPHERSON — Fort McPherson: base station, two portables
Good Hope: two portables

FORT NORMAN — Fort Norman: base station, two portables

FORT LIARD — Fort Liard: base station, two portables
Fort Liard Tower: portable

FORT SIMPSON — Fort Simpson: base station, two portables

HAY RIVER — Hay River: base station, two portables
Fort Providence: base station, portable
Kakisa Tower: portable

RAE — Rae: base station, two portables

YELLOWKNIFE — Yellowknife: base station, 2-4 portables
Yellowknife Tower: portable
Snowdrift: cache of portables (during high-hazard periods only)

FORT RESOLUTION — Fort Resolution: base station, two portables
Tsu Lake Tower: portable

FORT SMITH — Fort Smith: base station and a number of portables
Wood Buffalo Park: Warden Stations, listed below, are all equipped with base stations and portables:

Little Buffalo River
Pine Lake
Peace Point
Fifth Meridian
Carlson Landing
Sweet Grass Abattoir

27th Base Line
Chipewyan
Hay Camp Abattoir

Towers, listed below, are equipped with portable radio, except as noted:

Parsons Lake
Cherry Mountain
Peace Point (25-watt base station)
Davidson Lake (25-watt base station)
Caribou Mountain
High Rock
Carlson Landing
Hay Camp
Rocky Point

In addition to the above stations and equipment which form the radio communication network of the Game and Forest Management Sections, radio communication equipment is used by other divisions of the Northern Administration Branch in the MacKenzie District. It was not possible to get a complete account of this equipment, but the following is a list of some of the stations the radio equipment for which is supplied by the Department and maintained by Forestry, and which operate into the Forestry radio system and into the Department of Transport radio networks.

FORT WRIGLEY: station installed at the school for the Education Division

REINDEER STATION: station installed at the school and operated by the Education Division and the firm managing the Reindeer Station

LAC LA MARTE: station installed at the school for the Education Division

JEAN MARIE RIVER: station installed at the school for the Education Division

FORT FRANKLIN: station installed at the school for the Education Division

The radio network in the MacKenzie District is an HF double-sideband, amplitude-modulated system, operating in the frequency range 2 to 6 mc/s. The equipment at the fixed stations, with one or two exceptions, was manufactured by Spilsbury and Tindall Limited, Vancouver, B.C. The portable equipment has been purchased from several firms, with Spilsbury and Tindall equipment predominating. All fixed-station installations are rated at 20 to 25 watts transmitter power, with the exception of Fort Norman and Fort Simpson which are 50 watts, and Fort Smith which is rated at 100 watts. Practically all the equipment has been purchased in the period between 1946 and 1957, and consequently much of it is obsolescent and, except for one or two pieces purchased after 1958, none of the fixed-station equipment meets current Department of Transport specifications.

All the fixed-station equipment was designed for multichannel operation, but only a few of the sets have been equipped for more than one channel (4270 kc/s). The radio equipment at the various sites, with the exceptions noted in Appendix A, appeared to be in good working order and, on test, operated properly. However, the station installations — that is, antennas, ground system, and lightning protection were generally poor. Most of the fixed-station radio equipment is designed for use with single-wire-feed horizontal dipole antennas, and at many locations they were incorrectly installed and in poor locations, the result of the installations being made by untrained personnel.

During the period of inspection, radio propagation conditions were quite good. No difficulty of any importance was noted in the handling of traffic. Interference from distant stations (chiefly West Coast shipping) was experienced by the western stations of the network during evening and early morning hours. The MacKenzie system was largely unaffected by the disturbed ionospheric conditions in August, which caused a communications blackout in the Yukon radio system, although similar conditions during the summer of 1961 caused a communications blackout in the area.

At a number of sites, locally generated electrical noise was of sufficient intensity and duration to interfere seriously with the operation of the system. In many cases it originated as ignition and brush noise in electric generating plants nearby. In the larger centers, Yellowknife and Whitehorse, it was caused by industrial electrical equipment in the vicinity.

At many of the sites marine types of radio equipment were being used, which require rechargeable lead-acid batteries for power. Since electric power is available at all fixed stations, this complication is unnecessary, except in cases of power-plant failure, and the added interference from the vibrator power supplies in the radio sets could have been avoided.

Maintenance of the radio equipment — and with this should be included, installation — can only be considered as unsatisfactory. Proper installation and maintenance of radio communication equipment in an area such as the MacKenzie District poses a serious problem. Generally there are three alternative solutions to this problem: first, maintenance and installation of the equipment by the supplier, either on a service-call basis or under contract; second, by a local radio repair service; third, by a staff maintenance technician. In the MacKenzie District the first is impracticable because the area is so distant from depots maintained by the equipment suppliers that cost of service would be prohibitive and the delay in effecting emergency repairs intolerable. The second is usually unsatisfactory since the only available technical help is that of the local domestic radio and electrical appliance service store. The third alternative is best if the radio system is large enough to justify it, and a competent person can be engaged. These three methods have all been tried at one time or another with varying de-

grees of success. For the past year the maintenance has been done at the Fort Smith Forestry Depot by an ex-Army technician, hired as a casual employee. He has the basic test equipment required and has adequate quarters. However, even taking into account the relatively short time he has had and possible delays in obtaining spares and repair parts, the number of items of unserviceable equipment in the shop (some 15), and the general state of the field installation, one could not consider him satisfactory.

## RECOMMENDATIONS FOR MACKENZIE RADIO SYSTEM

The kind of radio system to be used is determined by: the extent of the area and terrain over which communication is required; the type of service required; economic limitations, and the availability of alternative means of communication.

The relatively long distances (100-600 miles) between fixed stations, and the predominately flat terrain, preclude the use of VHF radio on an economically feasible basis. This radio service is essentially a protective one for forest and game management, although a considerable quantity of what amounts to commercial traffic is handled. Such a system does not have to have as high a degree of reliability as, for example, a commercial communications network. At the present time, the only alternative to the present Forestry HF radio system over a large part of the MacKenzie District is operated by the Department of Transport, and unfortunately it is also an HF system, and subject to the same drawbacks outlined in the section "Radio Frequency Propagation" earlier in this report. Land-line and radio relay long-distance telephone is available between Hay River, Yellowknife, Fort Smith, Rae, and Chipewyan. If present plans of commercial communication agencies proceed, long-distance telephone service should be available along the MacKenzie to the Arctic within two to three years. Radio will no longer be the only means of communication, and the importance of point-to-point radio communication will diminish. At the same time, the Forestry radio system will be able to fulfill to a greater extent its proper function as a protective system as is the case in other federal and provincial forestry protective systems.

As has been stated, VHF radio has many technical advantages over HF radio, but it is not economically feasible to adopt such a system in the light of the above, and despite the inherent lesser reliability of HF propagation, HF radio must continue to be used. However, the over-all reliability of the HF system can be increased considerably by improved equipment performance and installations, by the use of proper operating frequencies, and by the use of more efficient equipment and methods of transmission.

Specifically,

1) The present double-sideband amplitude-modulated system should be replaced

with a single-sideband system. In order that this change may be made gradually, what is known as "compatible" single-sideband (SSB) equipment will be required, so that it can be used with existing equipment in the system, especially the portable equipment, since at the present time SSB portable radio equipment is not available. All fixed stations, other than lookout towers should be equipped with SSB compatible transmitters of 100 watts peak-envelope-power (PEP) rating.

2) All fixed station transmitters and receivers should be equipped for operation on a minimum of four frequencies, to permit the most efficient transmission under varying propagation conditions. Since the forestry lookout radio equipment is required to communicate over relatively short distances, and only during the summer months, the appropriate frequency will not change rapidly or to any great extent, so that only one frequency is likely to be necessary during any one season of operation. The Fort Smith headquarters station should be equipped with sufficient additional receivers that all radio-frequency channels in use during a particular period may be monitored simultaneously.

3) The present installations at fixed stations and towers, with one or two exceptions, are inefficient, and the antennas poorly or quite incorrectly installed. The present fixed-station antennas are unsuitable for multichannel operation, and should be replaced with correctly installed antennas intended for this purpose. The single-wire-fed antennas now in use at lookout towers are inefficient and unsuited to this application and should be replaced (see Appendix C).

4) Existing radio equipment should be overhauled and put into good working order. A number of 12-volt battery-operated transmitter/receivers are installed at locations where 110-volt 60-cycle power is available. When SSB equipment is installed at these locations, these 12-volt transmitter/receivers can be used to advantage as tower equipment to replace the low-power portable sets. At a number of locations, locally-generated electrical noise was sufficiently strong to interfere with reception. At the outlying stations it should not be difficult to locate the sources and these should be suppressed. At the larger centers such as Yellowknife, Fort Smith, and Hay River it may not be possible to suppress all interference. If this cannot be done at Fort Smith, remotely controlled receivers should be installed at a site free from interference. The mobile radio sets which are now in stock at the Fort Smith depot should be repaired and put into service in the appropriate vehicles.

5) Adequate, skilled technical assistance should be obtained to take care of the installation and maintenance of radio equipment. In view of the size of the MacKenzie District radio system, the amount of equipment involved, the presence in the area of similar equipment which is owned and operated by the Department, and because of the lack of competent and satisfactory commercial maintenance facilities in the area, provision of a staff radio technician is cer-

tainly justified. It is recommended that the requirements for the position be drawn up, the position advertized, and a suitable person engaged. Adequate space for the maintenance of radio equipment should be set aside at the Fort Smith depot. (The space presently used by the casually employed technician, would appear to be of adequate size.) Basic tools and electronic test equipment should be provided. An appropriate stock of operating and maintenance spares should be set up, and a purchasing and following-up procedure instituted to ensure that an adequate supply of materials is on hand at all times.

## YUKON TERRITORY FORESTRY RADIO SYSTEM

Radio communication was first used by the Yukon Forestry Division in the late 1950's. A large part of the equipment has been purchased since 1958 and consequently is of fairly recent manufacture and meets Department of Transport specifications. As in the MacKenzie District, much of it has been purchased from Spilsbury and Tindall.

The Territory is divided into districts with headquarters at Whitehorse and warden stations at:

Beaver Creek
Haines Junction
Dawson
Mayo
Carmacks
Watson Lake
Teslin

The establishment of radio equipment for the Forestry Division is:

WHITEHORSE — headquarters: 90-watt base station, six 25-watt mobile stations, seven 1.5-watt portable radios (portable radio pool)
Haeckel Tower: 30-watt station

BEAVER CREEK — warden station: 25-watt base station, two 1.5-watt portable radios

KLUANE — summer patrol station: one 1.5-watt portable radio

HAINES JUNCTION — warden station: 25-watt base station, two 1.5-watt portable radios

MAYO — warden station: 25-watt base station, two 1.5-watt portable radios
Stewart Crossing Tower: 30-watt station

CARMACKS — warden station: 25-watt base station, two 1.5-watt portable radios

ROSS RIVER — summer patrol station: one 1.5-watt portable radio

WATSON LAKE — warden station: 25-watt base station, two 1.5-watt portable radios
Tom Creek Tower: 30-watt station

TESLIN — warden station: 25-watt base station, two 1.5-watt portable radios
Tagish Tower: 30-watt station (under construction since July 1962)

DAWSON — warden station: 75-watt base station, two 1.5-watt portable radios

All radio equipment in the Yukon system is double-sideband amplitude-modulated and intended for operation in the band 2 to 6 mc/s. Base, mobile, and transistorized tower stations are capable of multichannel operation in this band, and the low-power portable sets of two-frequency operation. Base station transmitters are rated at 25 watts output, with the exception of the Whitehorse transmitter which is rated at 90 watts and the Dawson transmitter rated at 75 watts. All are operated from 110-volt 60-cycle power lines. The tower sets are newly purchased, battery-operated, transistorized units with a power output of 30 watts. Portable equipment has a rated power output of 1.5 watts and the mobile equipment 25 watts.

Several of the base stations are equipped with transmitter and receiver crystals for operation on two channels (4270 and 5730 kc/s). However, except for two or three installations, no antennas were available for operation on 5730 kc/s, and only the 4270 kc/s channel is in use.

Radio equipment, except in one or two instances was in good working order (see Appendix A). On the other hand, installation of equipment and antennas at the various stations left something to be desired.

The radio transmitters and receivers used in the system are designed for use with single-wire-fed antennas, either end-fed random length, or horizontal half-wave dipoles. Antennas at all installations are of the latter type. They are easily constructed and erected and are relatively easy to adjust. However, they are a compromise design, and must be erected over earth of good conductivity, and certain precautions must be taken in erecting them to obtain reasonable efficiency. Good radio ground conditions are not prevalent in the Yukon, many of the antennas are located in poor positions such that they are obstructed by nearby trees, buildings, and power lines, and in addition at some stations where antennas have been installed for 2 or 3 frequencies, these have been mounted on a common pair of poles so that there is a great deal of unwanted coupling between the antennas and transmission lines, a condition which seriously degrades the antenna performance. The Mayo and Whitehorse installations are typical of this condition.

The 110-volt 60-cycle power for the warden stations with the exception of that for the Dawson warden station where the line voltage regulation is very poor, is satisfactory at all installations. Electrical interference was sufficiently strong at a number of stations to impair reception seriously, particularly at Beaver Creek, Mayo, and Whitehorse. This interference originated from local power plants, electrical equipment, and fluorescent lamps.

Operation of the radio system could be considered satisfactory during the period of the inspection trip (the first part of July). Signal levels were adequately strong to overcome ambient noise and traffic was being handled without difficulty. Some instances of interference from other stations were evident but were not of serious proportions. Long-distance skip interference was not evident during daylight hours, and thus did not interfere with the normal daytime operation of the radio system.

However, it should be noted that during July, relatively quiet ionospheric conditions prevailed. Late in August a report was received of almost complete communication blackout in the area, with increased long-distance interference during the first part of August. This coincided with a period of disturbed ionosphere.

At the present time, owing to the lack of other more suitable maintenance facilities, repair and adjustment of the forestry's radio equipment is being done by the technical staff of the Whitehorse detachment, Royal Canadian Mounted Police. Since it is only natural that RCMP radio work takes precedence over repairs for the forestry section, such repairs are often delayed. Furthermore, since the RCMP staff have not the time to install the forestry radio equipment at warden stations and towers, this work has to be done by the wardens, with what assistance and instructions can be obtained from the equipment manuals. These manuals are reasonably detailed, but the men are technically untrained, and they can take only the most literal interpretation of the instructions, with consequent errors in the installation of the radio equipment and antennas and omission of the final adjustment and alignment of equipment which is necessary to obtain maximum performance. This situation explains the relatively good condition of the radio equipment, but the rather poor way in which this equipment is installed.

## RECOMMENDATIONS FOR YUKON RADIO SYSTEM

In making recommendations for improving the reliability of the Yukon forestry radio system, consideration should be given to alternative forms of radio communication as well as to measures which can be taken to improve the existing system.

The present system is composed of modern equipment of a kind which is suited for the type of service in which it is being used. The major cause of system failure

is not equipment breakdown but changes in propagation conditions. A significant increase in system reliability can be obtained by improvement in station installation, particularly with regard to antennas and by the use of more than one operating frequency. Some further improvement can be obtained by an increase in transmitter power, but this would not be justified since a greater improvement can be obtained with single-sideband equipment of the same nominal power rating as is now used.

However, none of these measures will eliminate or reduce to a satisfactory level the effect of the vagaries of ionospheric transmission which are inherent in an HF communications network and which are the cause of complete system failure. Consideration should therefore be given to an alternative form of radio communication with a higher order of propagational reliability, i.e., a VHF system. As pointed out earlier in this report, the advantages of VHF radio are the increased reliability, ease of operation, and suitability to mobile and portable operations. The major disadvantages are its limited range under certain conditions of terrain and the cost of developing a communication network to cover a large area.

The topography of the southern Yukon is excellent for VHF operations. It is mountainous country but the mountains are relatively low, rounded, and in many instances the tops are relatively easy of access — in fact, ridiculously so by helicopter. Valleys, in many cases, are quite broad and unobstructed, so that line-of-sight transmission over quite long distances (up to 50 miles or more) is possible. In addition, the high hazard areas and the main areas of operation of the forestry service lie along the major highways in the territory, so that both mobile and portable coverage can be provided with a minimum of stations.

However, while the cost of basic VHF radio equipment is comparable with that of HF equipment, the cost of establishing a given communication circuit using VHF may be many times that using HF because of the additional radio equipment required at repeater stations and the cost of developing and supplying power to these repeaters. For instance, a single-frequency simplex radio channel can be provided between points 300 miles apart using HF for a cost of some $2500.00, since radio equipment is required only at the terminal points of the circuit and the equipment can readily be housed in existing buildings. To provide a similar service at VHF would cost between $100,000.00 and $180, 000.00, since from six to ten repeater stations with buildings and power plants would be required, depending on the intervening terrain on the path, availability of commercial power, and climatic conditions.

Therefore, it is desirable to determine the approximate cost of providing a VHF radio system for the Yukon. In order that this can be done, it is assumed that communication is required between all warden stations and forestry headquarters from Watson Lake to Beaver Creek and Dawson and, in addition, to vehicles,

lookout towers, fire crews, and aircraft. To connect the fixed stations, a chain of repeaters will be required whose route would logically follow the highways. Mobile radio coverage will require, in addition, mobile repeaters at as many of the trunk repeater sites as is necessary to give the desired coverage. Spacing of repeaters will depend on the terrain and the availability of suitable sites. The most difficult part of the route is the portion between Watson Lake and Whitehorse. From Whitehorse to Beaver Creek and from Whitehorse to Dawson, the country is more open and larger repeater spacing is possible.

An engineering analysis based on information obtained from topographical maps and a field survey of the route is necessary to determine the number of stations required and an accurate estimate of the cost.

The following are possible alternative solutions to providing a basic network consisting of a trunk relay connecting forestry headquarters and warden stations and mobile repeaters to give mobile radio coverage on the highways. Cost of lookout tower, mobile and portable radio equipment is not included in these estimates since this equipment and its cost would be the same in each of the schemes.

1) The Yukon forestry section could install a basic radio system completely independent of existing systems or facilities. This would consist of base stations at Whitehorse and at the following warden stations:

Watson Lake
Teslin
Haines Junction
Beaver Creek
Carmacks
Mayo
Dawson

Radio relay trunk repeater stations would be required at approximately the following locations:

Swan River
Johnson Crossing
Tagish
Whitehorse
Haines Junction
Burwash Flats
Tantalus Butte
Stewart Crossing
Gravel Lake

Trunk terminal stations would be necessary at:

Rancheria
Beaver Creek
Dawson

In order to provide reasonably complete radio coverage of the two highways for mobile operations, mobile radio repeater stations would be required at:

Rancheria
Swan River
Johnson Crossing
Whitehorse
Haines Junction
Burwash Flats
Beaver Creek
Tantalus Butte
Stewart Crossing
Dawson

Cost of radio equipment, power plants and buildings under the above scheme is approximately:

| | | | |
|---|---|---|---|
| 9 | trunk repeater stations | ($9,300) | $ 83,700 |
| 3 | trunk terminal stations | ($9,300) | 27,900 |
| 10 | mobile repeater stations | ($2,200) | 22,000 |
| 8 | base stations | ($1,400) | 11,200 |
| | | | $144,800 |

The above costs do not include those of access roads to repeater sites or other repeater site development.

2) Since Canadian National Telecommunications have a developed and operating microwave relay system on the route of the Alaska highway with repeater sites ideally located for a VHF radio relay system, if the cooperation of the Company could be obtained with regard to the use of the sites, purchase of power and possibly, use of existing equipment buildings, a major portion of the capital cost of the system could be avoided. This saving, of course, would apply only to the Alaska highway portion of the system. Since there are no facilities of this nature on the Dawson road, Forestry would have to develop repeater sites on this route. This scheme could be carried out in two ways:

(a) Use of Canadian National Telecommunications sites and power systems, but installation by Forestry of a complete system as

under (1). The cost of power plants and site development on the Alaska highway would be saved and the costs would now be approximately:

| | | | |
|---|---|---|---|
| 6 | trunk repeaters | ($5,700) | $ 34,200 |
| 3 | trunk repeaters | ($9,300) | 27,900 |
| 2 | trunk terminals | ($5,700) | 11,400 |
| 1 | trunk terminal | ($9,300) | 9,300 |
| 10 | mobile repeaters | ($2,200) | 22,000 |
| 8 | base stations | ($1,400) | 11,200 |
| | | | $116,000 |

If Forestry radio equipment could be housed in Canadian National Telecommunications repeater equipment buildings, a further saving of some $3,000 each for the six repeaters and two terminals on the Alaska highway could be effected, giving a total system cost of $92,000.

(b) If, in addition to using Canadian National Telecommunications repeater sites, buildings, and power systems, a trunk circuit were leased from the company, trunk repeater equipment would not be necessary on the Alaska highway part of the system and the cost would be:

| | | | |
|---|---|---|---|
| 10 | mobile repeaters and buildings | ($2,200) | $22,000 |
| 3 | trunk repeaters | ($9,300) | 27,900 |
| 1 | trunk terminal (Dawson) | ($9,300) | 9,300 |
| 8 | base stations | ($1,400) | 11,200 |
| | | | $70,400 |

There would, however, be an additional operating charge of some $2,300 per month for rental of the trunk circuit (based on an assumed charge of $4.00 per mile per month).

It should be noted that in the foregoing schemes, only a minimal system is indicated which would give push-to-talk single-channel simplex communication. Furthermore, in order to realize the full capability of VHF radio in providing reliable communication, adequate maintenance is essential to retain equipment reliability. It is difficult because of the various possible alternatives to estimate the maintenance requirements. However, it is perhaps indicative that the Canadian National Telecommunications system, while admittedly more complex than any system required by the forestry section, requires a staff of some 60 to keep it in operating order.

Although the initial cost of a complete basic VHF radio network may be so large

that it cannot be considered at the present time, VHF radio as a solution to the communication problems being encountered in the Yukon is so attractive that some scheme which would permit a gradual transition from HF to VHF communications over a period of years is most desirable. The following is a proposal for the institution of a hybrid system in which, initially, present HF facilities would be used for long-distance communication between fixed stations and VHF radio for local, mobile, and portable communication. Commercial telephone circuits would be used for long-distance communication during times of unreliable HF communication.

The VHF portion of the system would be expanded gradually to fill in gaps between stations and increase coverage. As the proportion of VHF equipment is increased and the need for the HF equipment becomes less, it may be taken out of service.

A plan for the complete system will be essential at the start to ensure that appropriate equipment is purchased for the initial stages which will be compatible with equipment installed later, and to ensure that system radio licenses and frequency assignments are obtained to permit logical, efficient expansion of the system.

The first stage in the implementation of this plan would be to equip the station in the area having the greatest traffic density, that is, the one centered on Whitehorse. The system then can be expanded in a logical manner outwards from Whitehorse along the three highways so as to take in the remainder of the warden stations.

The following complement of radio equipment is suggested for the initial installations:

WHITEHORSE: one base station, six mobile sets, six portable sets

HAECKEL TOWER: one 20-watt battery-operated transceiver*

HAINES JUNCTION: one base station, one mobile set (warden's vehicle), one 20-watt battery-operated transceiver* (at tower, if built), one portable

CARMACKS: one base station, one mobile set (warden's vehicle), one 20-watt battery-operated transceiver* (at tower, if built)

TAGISH TOWER: one 20-watt battery-operated transceiver*

*20-watt mobile units equipped for operation as two-frequency repeaters

All radio equipment would be for two-frequency operation in the 152-174 mc/s band. The tower sets would be 20-watt transistor battery-operated mobile units equipped for operation as two-frequency "Mobilerepeaters", but also capable of

operation by the tower men. Should it be desired to install a trunk relay system at any time during the implementation of this communication plan, the above equipment would be compatible with such a plan.

It is not possible to specify at the present the range of communication which could be obtained with the above installations. This would require a field survey to determine signal levels and range of communication. However, at least one government service, the Royal Canadian Mounted Police, is obtaining mobile communication coverage from Whitehorse to Haines Junction and nearly to Carmacks, without the use of intermediate repeaters. Similar results could be expected with a base station located at Forestry headquarters in Whitehorse and, during the summer when Haeckel and the other towers are equipped, and especially if towers are built at Haines Junction and Carmacks, coverage should be obtained as far as Burwash Flats, Johnson's Crossing and past Stewart Tower on the Dawson road.

A detailed breakdown of equipment needed for the foregoing, and approximate costs, is given in Appendix B.

## SUMMARY

The catastrophic failures of the forestry communications systems of the Northern Administration Branch in the Yukon Territory and MacKenzie District have been caused primarily by ionospheric radio conditions. However, this effect has been compounded by faulty equipment, maintenance, and installation. Complete communication reliability cannot be obtained using HF radio, but improved propagational reliability can be achieved by using VHF radio where practical, and HF system reliability can be increased by the use of more efficient communication techniques and improved station installations and equipment maintenance.

Consequently, it is recommended that in the Yukon Territory, where VHF communication is feasible, a change be made to this method to realize increased propagational reliability. Initially, the present amplitude-modulated HF equipment can be retained for long-distance point-to-point communication, augmented by long-distance telephone and VHF communication used for mobile and portable operations. In the MacKenzie District, where it is not feasible because of cost to make use of VHF communications, it is recommended that improved system performance be obtained by replacing the present obsolete amplitude-modulated equipment with modern, compatible single-sideband equipment.

Although this report is concerned primarily with the operations of the forestry radio systems, it became apparent during the course of the survey that there is little or no coordination of the telecommunications requirements of the various divisions and groups of the Department operating in the North. This situation has

resulted in inefficient purchasing and maintenance of equipment, duplication of services and equipment, waste of communication channels, and mutual interference between systems. Therefore, it is strongly recommended that an agency be set up within the Department to coordinate all its telecommunications needs, giving proper consideration to the use of commercial telecommunications facilities.

## Reference

1. "A Study of Communications in Northern Canada" — The Trans-Canada Telephone System, Montreal, April 1962

## ACKNOWLEDGEMENTS

The author is indebted to Mr. R.T. Flanagan of the Department of Northern Affairs and National Resources for assistance in making the survey and preparing this report, to the superintendents of forestry of the Yukon Territory and the MacKenzie District, Mr. D.F. Merrill, and Mr. R.H. Kendall and the members of the warden services for their cooperation and assistance, and to the members of the staffs of the Bell Telephone Company, Canadian National Telecommunications, and Alberta Government Telephones, who helped greatly in providing information on commercial communications systems.

# APPENDIX A

## FIELD NOTES ON CONDITION OF RADIO SYSTEMS (JULY 1962)

## YUKON TERRITORY

### WHITEHORSE

Forestry Headquarters Station The radio station is located in the headquarters office building with the transmitter/receiver in the general office. The office clerk acts as operator and despatcher so that the station is manned during office hours. The transmitter/receiver is a Model LRT-900 built by Spilsbury and Tindall. It is equipped for two-frequency operation — 4270 and 5730 kc/s. Two resonant antennas, one for each frequency are installed. The antennas are off-center-fed dipoles mounted on a single pair of poles with about five-foot separation between them and they are located about 100 feet from the transmitter. The feeders run quite close to each other throughout their length. Antennas are located between two buildings and at about the same level as the top of the office building. Mutual coupling between antennas, and between transmission lines, and obstructed antenna location is not good. Some locally generated electrical noise is noticeable.

Mobile Equipment Six Whitehorse-based forestry vehicles are equipped with S and T MRT-200 mobile transceivers and center-loaded whip antennas. These are equipped for two-frequency operation. Two installations were inspected and appeared to be in good operating condition.

Portable Equipment Seven S and T PRT-20, 1.5-watt transceivers are kept in a pool of equipment for use throughout the Territory.

Haeckel Tower The tower is equipped this season with an S and T TRT-300 30-watt transistorized transceiver. This installation was not inspected but the strength and quality of the transmissions from this station indicated that it was working well.

Note: All towers are now being equipped with these sets.

Other Equipment Two S and T type AD-10 transceivers which are now obsolete and have been declared surplus, are being used for monitoring and emergency purposes by the chief warden and fire control officer at their homes.

### CARMACKS

The radio station is in the warden's office and the equipment is an S and T

MRT-200 transceiver equipped for 4270 and 5730 kc/s operation. A single off-center-fed dipole tuned to 4270 kc/s is the only antenna. The equipment had normal receiving sensitivity, and field strength reports from other stations in the network indicated normal transmitter operation. Some Morse interference was noticed at the time of inspection (10:00 a.m.).

Portable Equipment The S and T PRT-20 portable set was in operating condition. In order to test it, it was connected to the station antenna and the warden was asked to tune it. It was found that he was resonating the transmitter final amplifier and loading the set incorrectly. He was shown the proper procedure and several stations of the network were contacted.

Telephone A dial telephone in the warden's office is connected to the Carmacks exchange with a long-distance toll connection to Whitehorse.

Note: All warden stations in the Yukon have dial telephone service.

## STEWART CROSSING TOWER

The tower had recently been completed and was temporarily equipped with a PRT-20 transceiver. A temporary off-center-fed dipole was mounted on tripods about ten feet off the ground. The antenna tuning control of the set had an intermittent fault and was in need of maintenance. The set was tuned and Haeckel tower was contacted. The report received from the tower indicated satisfactory operation of the set.

## MAYO

The radio station in the warden's office had an MRT-200 set equipped with an antenna coupling unit for three frequencies: 4040, 4270, 5730 kc/s. The warden reported best results were obtained on 4270 kc/s, using the 4040 kc/s antenna. This indicated improper adjustment of antenna coupler and/or incorrect antenna length. The three dipoles are mounted one above the other on a common pair of poles about 25 feet in height. The antennas are across an alley from the building and the feeders cross a power line and run close to the building power service leads. The warden's office is in the same building as the mines office. The building is equipped with fluorescent lighting that causes considerable interference. The same remarks concerning antenna efficiency apply here as for Whitehorse.

## DAWSON

The warden station transceiver is an S and T MRT-600, rated at 75 watts, equipped with crystals for operation on 4040, 4270, and 5730 kc/s. The set was

inoperative owing to a blown line fuse. The fuse was replaced, but the new fuse also blew, indicating internal malfunction of the equipment. Since the warden was away on duty, no attempt was made to correct the fault. The antenna was an off-center-fed dipole.

BEAVER CREEK

The warden station set is an S and T MRT-200. The antenna installation was excellent. It was erected in cooperation with the Canadian National Telecommunications staff. Local power is provided by the Department of National Defence diesel plant. Extreme power line interference ruined otherwise excellent receiving conditions. At Beaver Creek there was a Canadian National Telecommunications microwave and VHF telephone drop from the Alaska microwave relay.

TESLIN

The warden station set is an MRT-200. The equipment was in good condition, with good antenna setup: a single antenna, cut for 4270 kc/s. Transceiver was equipped for 4270 and 5730 kc/s.

Portable Equipment The PRT-20 set was out of commission.

WATSON LAKE

The warden station set is an MRT-25. Set and antenna were in good shape and were properly installed.

## MACKENZIE DISTRICT

FORT LIARD

An excellent installation. The equipment was an S and T LRT-60 set with a horizontal dipole antenna fed with a balanced transmission line equipped with lightning arrestor. One channel, 4270 kc/s, was in use. Some two-hop interference started about 5:00 p.m., local time and continued during the night. It was still prominent at 8:00 a.m. Whitehorse and other Yukon system stations were being strongly received at this time. There was considerable QRM from West Coast shipping. Some local interference was noticeable from the RCMP power plant nearby. Watson Lake was worked, strength R3, at 9:30 a.m., although that station did not answer the previous evening.

Note: The Hudson's Bay Post was equipped with a CROSBY compatible SSB, 50-watt set, dipole antenna, 72-ohm ribbon feeder. The Hudson's Bay factor carried out a schedule with Wrigley at 9:15 a.m. There was a noticeable decrease in noise and improvement in signal intelligibility compared with forestry installation. Equipment is that which was adopted by S.G.L. Horner in the early 1950's for the Hudson's Bay Company radio network.

## FORT SIMPSON

The warden station radio equipment is a Marconi Seafarer with eight crystal-controlled channels and broadcast band reception. It is equipped for operation on 4270 and 5730 kc/s. Two antennas, both for 4270 kc/s, are erected at right angles to each other. The equipment is working well, but distortion on received signals indicates that the receiver is not properly tuned to the network frequency.

## FORT NORMAN

The warden station is located on 50-foot bluffs on the east bank of the river. The radio equipment is an S and T LT-552 set which is obsolescent and not an approved type. It is equipped with one crystal for operation on 4270 kc/s. The antenna is a horizontal dipole cut for 4270 kc/s and fed with a twisted-pair feeder. The antenna is erected satisfactorily, but insulation is falling off the feeder conductors, and the transmitter end of the feeder conductors was twisted together and connected to one output terminal of the transmitter although the transmitter is intended for operation with a balanced line. The transmitter was completely mistuned. The transmission line was repaired and reconnected as a balanced pair to the transmitter and retuned according to the manual. The author was unable to make contact from an aircraft on the way to Norman Wells and found on return that the final amplifier was doubling to 8540 kc/s because of mistuning, largely due to ambiguous instructions in the manual. This was corrected, and the set operated properly. Previous adjustments to the transmitter had been made by a CBC technician from Inuvik.

## FORT FRANKLIN

The equipment here is an S and T MRT-25 set lent by Forestry to the school office. The antenna is a single-wire-fed dipole. The equipment was in satisfactory condition except for excessive audio hum probably due to a faulty filter capacitor. A message was passed to Fort Liard for retransmission to Fort Norman, as we were unable to work Fort Norman directly owing to conditions being unfavourable for short-haul communication. The report from Liard was 2 × 3. The fact that Whitehorse was being received at Franklin at strength 9 at this time was indicative of prevailing conditions.

LAC LA MARTE

Radio equipment was located in the teacher's residence, on loan from the Forestry section. The radio appeared to be in good condition, but two antennas were connected to the set simultaneously, in addition to a third piece of wire which disappeared over the roof.

RAE

The radio equipment is an S and T LRT-25 set designed for single-wire feed, but was connected to the antenna with a twisted pair, one conductor being connected to the set's antenna terminal and the other to ground. The feeder was touching the power standpipe of the office and mixed up with another cable running from the office to the warden's home.

YELLOWKNIFE

The radio equipment was located in the forestry depot office near the water's edge in Old Yellowknife. The equipment is an S and T MRT-25 set with 12-volt vibrator and genemotor power supply operating from a 12-volt battery being charged from the 110-volt line. A battery power supply was being used to reduce interference from a nearby woodworking plant despite considerable interference from the vibrator supply. The audio gain control of the receiver was not working properly, either because of a faulty control or amplifier tube. The battery supply should be replaced by a 110-volt supply, and line filters should be installed.

FORT PROVIDENCE

The radio equipment is an MRT-25 set and was operating satisfactorily although the antenna feeder was in contact with the metal chimney of the house.

HAY RIVER

The radio equipment is a very old S and T 50-watt set with no model or serial number showing. It is equipped for operation on 4270 kc/s with off-center-fed dipole. The speaker muting switch was inoperative, so that manual control of the receiver was required when transmitting in order to avoid feedback. The operator reported getting good results with the equipment except for heavy adjacent channel interference from the local Department of Public Works transmitter on 4250 kc/s.

FORT SMITH

The MacKenzie District forestry headquarters station is located in the forestry

depot. The equipment is an MRT-50 set with single-wire-fed antenna, together with a rather old S and T 150-watt transmitter. This latter unit was inoperative, but so far as could be determined only minor work was required to put it into operation.

CARLSON LANDING

The radio equipment was an MRT-25 set with battery supply despite the fact that the warden station is equipped with 110-volt power. The antenna is off-center-fed, but the feeder was attached to the midpoint of the antenna instead of to the 300-ohm point. The equipment was operative otherwise.

SWEETGRASS

The MRT-25 set in the superintendent's office operated satisfactorily but here again the antenna was incorrectly fed.

FORT CHIPEWYAN

The radio transceiver was built by the Ontario Department of Lands and Forests. The output was 50-watts. Two-channel operation is provided, with ability to select either one or both channels simultaneously for reception. There was a dipole antenna with unbalanced coaxial line feeder. The set is equipped for two frequencies: 4270 kc/s and an Ontario Lands and Forests frequency.

Note: There is also an Alberta Lands and Forests station at Chipewyan. The radio equipment is a Kaar 9-channel set of recent manufacture with a single antenna fed with a 72-ohm ribbon feeder. In addition, the station has an S and T transistor battery-operated receiver for monitoring aircraft radio channels.

HAY CAMP

The base station is a battery-operated MRT-25 set despite 110-volt power being available. The antenna is an off-center-fed unit, but the feed point is far too close to one end for proper matching. An S and T mobile set in storage is purported to be for Wood Buffalo Park bombardier vehicle.

HAY CAMP TOWER

The radio is an S and T PRT-20 1.5-watt battery unit in the tower cupola. A single wire feed runs to a horizontal dipole strung between a tree and the tower, so that the feeder drops from the cupola to the antenna. Both the antenna and feeder were so slack that the feeder was wrapped around the antenna for some

distance between the feedpoint and the end of the antenna.

Note: It might be better to use a whip antenna at the towers — the effective radiation would be about the same and would result in a much neater installation.

## PINE LAKE WARDEN STATION

The radio equipment is an MRT-25 battery-operated set, as above. Both the radio and antenna were in good condition.

## PINE LAKE TOWER

The radio equipment, an MRT-25 set equipped for 4050 and 4270 kc/s was located in the cupola. A 12-volt battery and Chore Horse charging unit were in a shed at the base of the tower. A pair of no. 6 wires carries power to the set. The voltage drop in the leads, when transmitting, was considerable. The transmitter was off tune. The tower man had no idea what the controls were for, but believed that the audio gain control changed the battery voltage — a logical if erroneous conclusion. This point was cleared up, and he was instructed in proper adjustment of the transmitter using tuning control and neon indicator on set. The antenna situation was the same as for Hay Camp Tower.

## FORT RESOLUTION

The radio equipment was located in the warden's office. The equipment was in good condition, but the station installation and antenna were bad. The antenna is too low (probably because the station is located on the glide path of the airport) and runs through the tops of a small grove of poplars. The feeder enters the office at one window and runs around two walls of the room to the transmitter. The station ground was very poor and the connection to the ground rod was intermittent.

# APPENDIX B

## EQUIPMENT REQUIRED TO IMPLEMENT RECOMMENDED SYSTEMS

## MACKENZIE DISTRICT RADIO SYSTEM

1) Fort Smith

| | | |
|---|---|---|
| One 4 to 6 channel, compatible, 100-watt PEP, SSB transmitter/receiver for operation in the frequency band 1.5 to 16 mc/s | $2,500 | |
| Two 4-channel monitor receivers, each $1,000 | 2,000 | |
| One broad-band transmitting/receiving antenna | 150 | |
| One broad-band receiving antenna | 150 | |
| | $4,800 | $4,800 |

2) Warden and other fixed stations, as required

| | | |
|---|---|---|
| Per station: one 4 to 6 channel, compatible 100-watt PEP transmitter/receiver for operation in the band 1.5 to 16 mc/s | $2,500 | |
| One broad-band transmitting/receiving antenna | 150 | |
| Approximately 18 installations required, each at | $2,650 | 47,700 |
| | | $52,500 |

3) Mobile Stations

| | | |
|---|---|---|
| Estimated initial requirements: six 100-watt compatible SSB transceivers, each at | $2,500 | 15,000 |
| TOTAL COST OF NEW EQUIPMENT | | $67,500 |

4) Lookout Towers

Present 25-watt Spilsbury PRT-25, battery-operated equipment taken out of service at fixed stations can be used after modification for operation with balanced transmission-line-fed dipoles or with whip antennas.

## YUKON TERRITORY FORESTRY RADIO SYSTEM

### 1) WHITEHORSE

| | | |
|---|---|---|
| One 50-watt, 152-174 mc/s FM base station equipped for two-frequency operation | $1,200 | |
| One 4 db omnidirectional antenna complete with 100-foot tower and transmission line, installed | 800 | $2,000 |
| Six 25-watt mobile installations | | 4,500 |
| Six 1.5-watt portable sets | | 3,900 |
| Two 4-channel HF monitor receivers | | 2,000 |
| Haeckel Tower | | |
| One 20-watt transistor, battery-operated mobile set equipped for operation as a two-frequency mobile repeater capable of being locally operated, complete with 3 db ground plane antenna and duplexer | 2,500 | 2,500 |
| | | $14,900 |

### 2) HAINES JUNCTION

| | | |
|---|---|---|
| One 50-watt base station complete with 80-foot tower, 3 db ground plane antenna, installed | 1,500 | |
| One 25-watt mobile installation | 750 | |
| One 1.5-watt portable set | 650 | |
| Haines Tower | | |
| One battery-operated repeater complete, as for Haeckel Tower | 2,500 | $5,400 |

### 3) CARMACKS

| | | |
|---|---|---|
| Equipment as for Haines Junction | 2,900 | |
| Carmacks Tower | | |
| Equipment as for Haeckel Tower | 2,500 | $5,400 |

4) TAGISH

Tagish Tower

| | | |
|---|---|---|
| Equipment as for Haeckel Tower | 2,500 | 2,500 |
| | TOTAL | $28,200 |

## APPENDIX C

## CHOICE OF OPERATING FREQUENCIES

In the section of this report dealing with HF radio-frequency propagation (p. 2) the need for several radio-frequency channels in order to maintain reliable communication was emphasized. Referring to Figs. 4, 5, and 6 it will be seen that higher frequencies are required for the longer communication paths than for the shorter ones, and that a frequency for daytime communication is higher than one for nighttime. Fig. 4 shows that both day and night frequencies are lower during the winter than during the summer and that there is a greater change between day and night frequencies during the winter. Figs. 5 and 6 are, respectively, the predicted optimum traffic frequencies for January and July at times of sunspot minimum and maximum. It is evident from a comparison of these that present conditions are approximately the same as will prevail during the period of sunspot minimum predicted for 1964-65, with optimum frequencies in the order of 1.5 to 2.0 mc/s at night and 3.5 to 4.0 mc/s during the day. During the period of sunspot maximum expected for 1970-71 frequencies as high as 11 to 12 mc/s will be required.

During the summer of 1963 a frequency in the range of 5.5 mc/s will be suitable for the longer circuits during the hours 0600 to 1800, and one in the range 3 to 4 mc/s from 1800 to 0600. Similarly, day and night frequencies for the shorter distance will be in the order of 4 and 3 mc/s.

The Yukon and MacKenzie forestry services have presently assigned to them the following channels:

| | | | |
|---|---|---|---|
| 2.246 | 2.440 | 3.225 | |
| 4.050 | 4.270 | 4.610 | |
| 4.855 | 4.990 | 5.730 | mc/s |

Of these, only one, 4.270 mc/s is in use. It will be seen from Fig. 4 that during the summer of 1962 this frequency was a reasonably satisfactory compromise for short-distance communication throughout the day, but for the longer circuits it was too low — a frequency in the neighborhood of 6.5 mc/s would have been more suitable.

In order that sufficient frequency assignment be available to accomodate changes in optimum frequencies until the peak of the sunspot cycle, it is recommended that additional channels be requested, one in each of the following ranges: 1.6 to 1.8, 6.765 to 7.000, 9.040 to 9.995, and 11.400 to 12.330 mc/s. It would be most de-

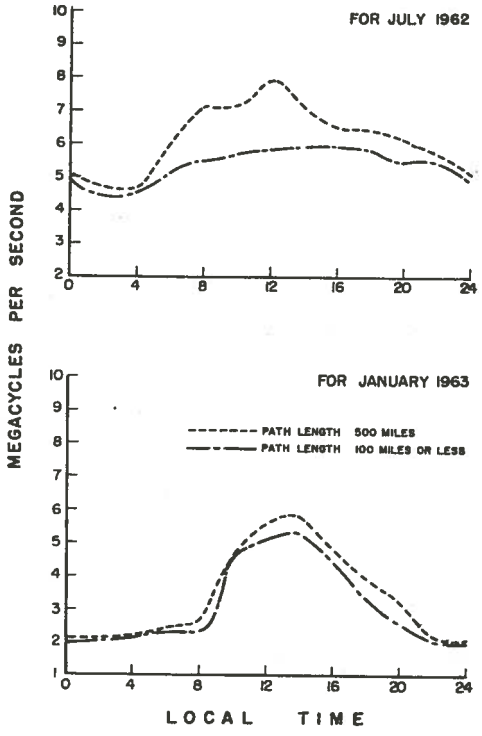



Fig. 4
(above) Optimum traffic frequencies for July 1962

(below) Optimum traffic frequencies for January 1962

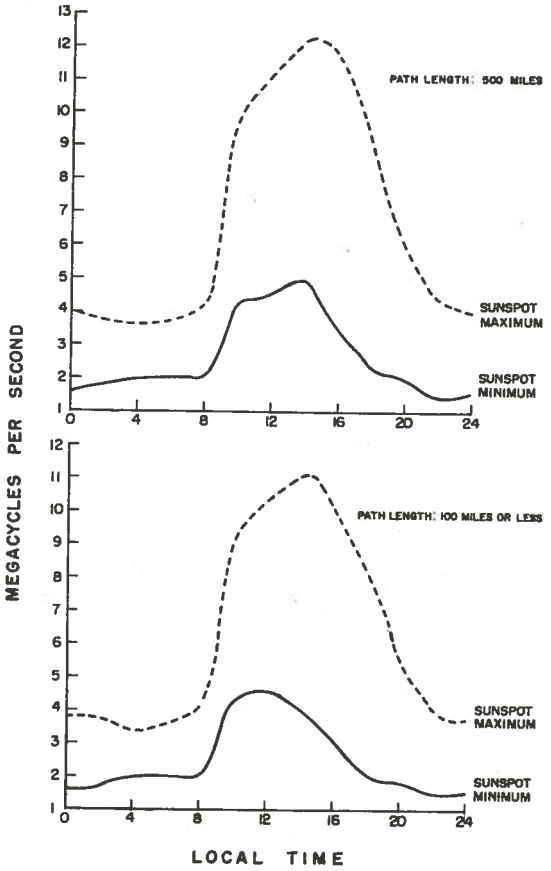



Fig. 5
Optimum traffic frequencies for January
Sunspot maximum and minimum

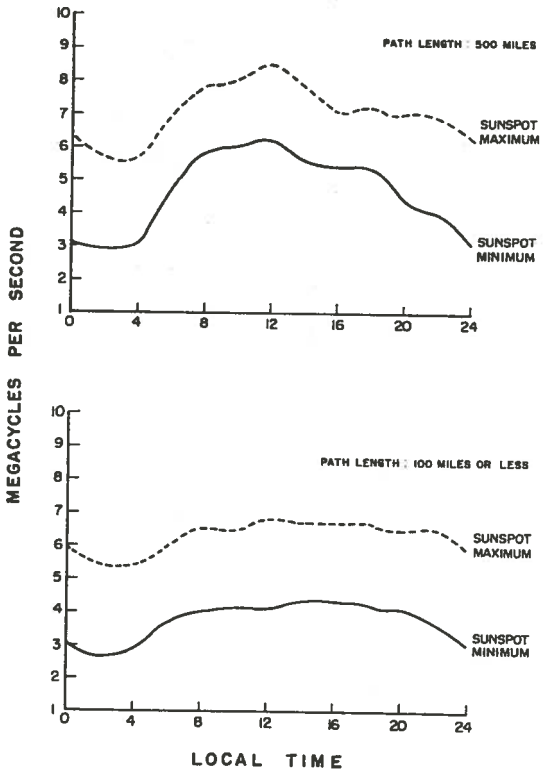



Fig. 6
Optimum traffic frequencies for July
Sunspot maximum and minimum

sirable to obtain an alternative channel to 4.270 mc/s, since it is a maritime mobile assignment. 4.610 mc/s, which is presently assigned, would be suitable if it is clear of interference. It is probable that listening tests will be necessary at Fort Smith and Whitehorse to locate frequencies which are free of interference before application should be made to the Department of Transport for additional assignments.

It should be noted that the limits of tuning range common to all types of equipment in use are 2.0 to 6.5 mc/s. In the Yukon where some of this equipment will be retained, this will limit the choice of operating frequencies. However, when new equipment is purchased for the MacKenzie system this can have an appropriate tuning range.

# APPENDIX D

## ANTENNA SYSTEMS

At present, all fixed stations, including fire towers, in the two radio systems are equipped with half-wave horizontal dipole antennas. These are with one or two exceptions, single wire off-center-fed units which are satisfactory for single-frequency operation when properly installed, but are inefficient when operated at other than their resonant frequencies. Hence, they are not suitable for multi-frequency operation. Since it is proposed that four radio-frequency channels be used in the future, either four separate single-frequency antennas or a single broad-band antenna will be required at each station. It would be impractical in a radio system of this kind to install a number of antennas to operate efficiently at any one site, and the cost of broad-band rhombic or log-periodic antennas would not be justified. The following types of antennas which can be operated with reasonable efficiency at a number of frequencies are therefore recommended:

### Warden Stations

A dipole antenna with resonant, open-wire transmission line and antenna-matching unit, as illustrated in Fig. 7, is recommended for these sites. With

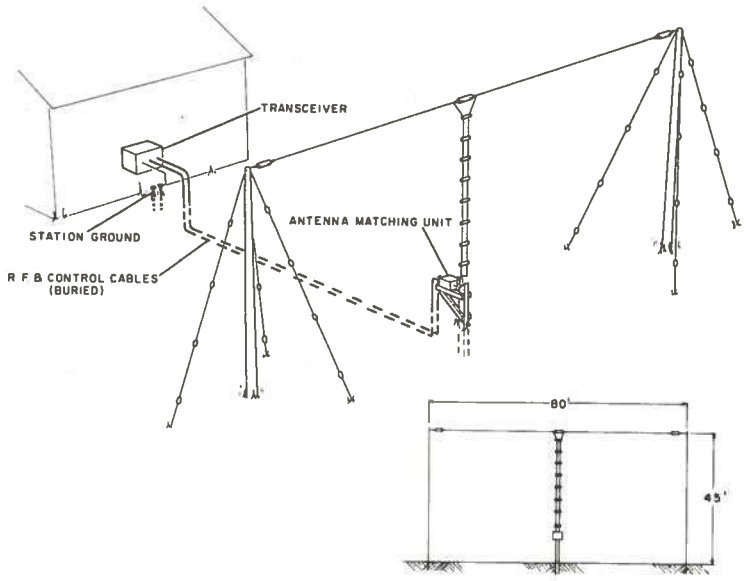



Fig. 7 Recommended warden station antenna system

such a system, the antenna may be located close to the radio building with the tuning unit adjacent to the transmitter, or if necessary to obtain a good site location, the antenna and the tuning unit may be located several hundred feet away and fed by a buried coaxial cable.

## Fire Towers

Since the requirements for the fire tower installations are not as critical as those for the warden stations, a whip antenna such as is used in mobile installations, will be sufficient. An advantage of this antenna is that it can be used with existing radio equipment without modification of the equipment.

## Remote Receiving Installations

It is recommended that the double-doublet antenna shown in Fig. 8 be used where it is necessary to have remotely operated receiving facilities.

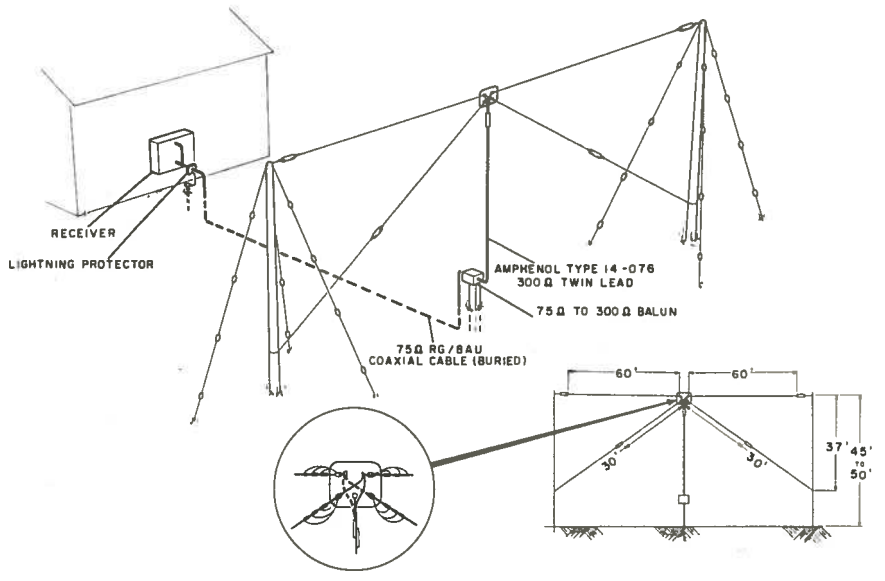



Fig. 8 Recommended remote receiving antenna system