

ENCOUNTERED BY MOBILE COMMUNICATIONS SYSTEM^{1/}

By

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Unattended automatic repeater stations are essential links in VHF radio communication systems providing mobile radio coverage of transportation and power transmission routes traversing mountainous areas of British Columbia. These repeater stations are invariably required to be sited at high elevations above sea level, with attendant high costs for construction and maintenance of access roads and power lines or alternative AC power sources, as well as unreliable operation of radio equipment, exposed to unfavourable conditions of low temperature, high velocity winds, heavy snowfall and severe icing. The difficulties encountered and the experience gained during more than ten years operation of these conventional repeater stations spurred the development of a packaged type battery-operated repeater station designed to eliminate requirements for access roads and power lines, protect antennas and other radio equipment from adverse weather conditions and ensure reliable and maintenance-free operation for approximately five years.

The complete packaged repeater station consists of low power VHF and UHF radio repeater units, an air-depolarized battery and various mobile and trunk repeater antenna systems, all housed in a cone-shaped fibreglass radome which is lifted to the selected site by helicopter.

The conical radome weighs 700 pounds, stands 28 feet high and has a diameter of 2 feet at the top and 7 feet at the base. A fibreglassed double-planked wood base, 8 feet in diameter and weighing 300 pounds, is bonded to the cone of the radome before or after lifting to the site, depending on lifting capacities of available helicopters. The lower 6 foot section of the radome is double-shelled and insulated and houses the radio repeater unit and battery. This section is rigidly braced and firmly fixed to the ground by rock anchors. The upper 22 foot section of the radome is self-supporting and uninsulated and provides isolation from wind, snow and ice for various antenna systems. A removable insulated ceiling separates upper and lower sections and access can be gained to both sections by water tight hatches with bolted-on covers. A nose cone ventilator provides a continuous supply of air for the air-depolarized battery and the remainder of the radome shell is airtight.

The mobile repeater unit is basically a 5 watt transistorized VHF hand-carried radiotelephone, with high stability crystals and a battery current drain of 5 mA in receive mode and 800 mA in transmit mode. The UHF trunk repeater unit is similar to the VHF mobile repeater but has a power output of less than 1 watt with a battery current drain of 300 mA. Shielding of transmitters and receivers and filtering of power leads provide sufficient isolation to prevent receiver desensitization in the transmit mode. Special techniques are employed to maintain high quality of the repeated audio signal and ensure continued proper operation of receiver squelch circuits during extremely low temperatures. Emphasis is placed on thorough testing of the unit to check its performance throughout the -40 to +100 degrees Fahrenheit temperature range before releasing it for installation at a remote site.

The battery consists of two, three or four parallel banks of 14 series-connected 2000 Ah air-depolarized cells, giving an 18 to 20 volts power supply which is regulated to the 15 volts required for the radio units. Assuming a generous 10 percent transmit and 100 percent receive duty cycle for repeater operation and using the current drain figures indicated above, the battery will provide for the operation of the repeater station for more than five years. Selective signalling of mobile repeaters reduces the transmit duty to much less than 10 percent and could extend the life of the battery to 10 years or more. The air-depolarized battery is not rechargeable and requires replacement at the end of its useful life. The cold temperature operating characteristics of this battery must be fully understood by the user.

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Standard antenna systems can be used in the radome but in this particular development special antennas have been designed to permit several systems to be accommodated in the same radome without harmful mutual interference. Since space is restricted, the VHF mobile repeater uses only one antenna for both receive and transmit, with the necessary isolation being obtained by a duplexer giving 100 dB isolation for 0.6 dB insertion loss with transmit and receive frequency separation of 700 kHz. The duplexer is enclosed with the repeater unit in a single moisture-proof fibreglass container in the bottom section of the radome. Cross-polarized 10 dB gain YAGI type antennas are used for the duplex UHF trunk circuits which interconnect repeater stations to provide remote control facilities.

The complete installation of the packaged repeater station is carried out by 4 men in approximately 8 hours. Personnel and equipment are lifted to the site by helicopter in a prearranged sequence which permits work to proceed inside and outside the radome simultaneously once the radome is in position. Total cost of a VHF mobile repeater station, including installation, is between \$ 10,000 and \$ 12,000, but this cost can be reduced to between \$ 6,000 and \$ 8,500, per repeater if two parties can share the same radome, antenna system and battery.

During the past four years, the BC Department of Highways and the BC Hydro and Power Authority have installed about sixty of the packaged repeater stations, about half of them on a shared basis, at elevations up to 9500 feet and the excellent performance of these units indicated that the former difficulties encountered in the severe environment of the mountainous areas of British Columbia have been overcome by this new repeater design.

As an extension of the above concept, a half-size radome housing a single VHF base station, antenna and battery together with interrogating, sensing and telemetering equipment has recently been installed at a remote snow course site as a prototype for similar installations which will provide telemetering of data to a central control point on interrogation of the remote station. The same basic radio equipment is used in this application but with less equipment and only four daily interrogations, each of a few seconds duration, the duty cycle is considerably reduced and economic advantages can be realized with the following changes in equipment.

The shelter is of similar construction to the repeater radome but is 15 feet high with a diameter of 2 feet at the top and 4 feet at the base. The fibreglassed base is permanently bonded to the cone and the total weight of the shelter is approximately 500 pounds which permits easy handling by truck and light helicopter. The lower 6 foot section is double-shelled and insulated and provides ample room for the reduced quantities of batteries and radio equipment. Earth anchors, instead of rock anchors, are normally used to fix the shelter to the ground in the more sheltered locations of the snow courses. The upper and lower access doors are retained along with the sectionalized insulated ceiling, since snow is expected to pile up around this shelter rather than blow away as in the case of the more exposed repeater stations.

The VHF radio transmitter/receiver unit is the same unit used for the VHF repeater unit, except that with no insertion loss of a duplexer to provide for, the 2 watt version with its 400 mA current drain can be used to reduce the quantity of batteries required. Thorough environmental testing of each unit is carried out prior to installation at the snow course.

The reductions in current drain and duty cycle permits the use of a smaller battery pack consisting of 8 two-cell air-depolarized batteries of 1200 ampere hour capability. With the 5 mA standby and 400 mA transmit current drains, a duty cycle of 1 percent transmit and 99 percent receive, this battery pack will provide for operation of the base station for 10 years or more.

A single vertically polarized folded dipole antenna is mounted in the top section of the radome, with the dipole oriented in the direction of the nearest VHF repeater station.

Installation of the shelter and radio equipment at a snow course is carried out by 4 men in approximately 4 hours. Total cost of this portion of the station, including installation costs is between \$ 6,000 and \$ 7,000, depending on the costs for helicopter services for a particular site.

Snow pack, temperature and precipitation measuring equipment as well as the telemetering equipment is supplied and installed by other parties and is beyond the scope of this paper.

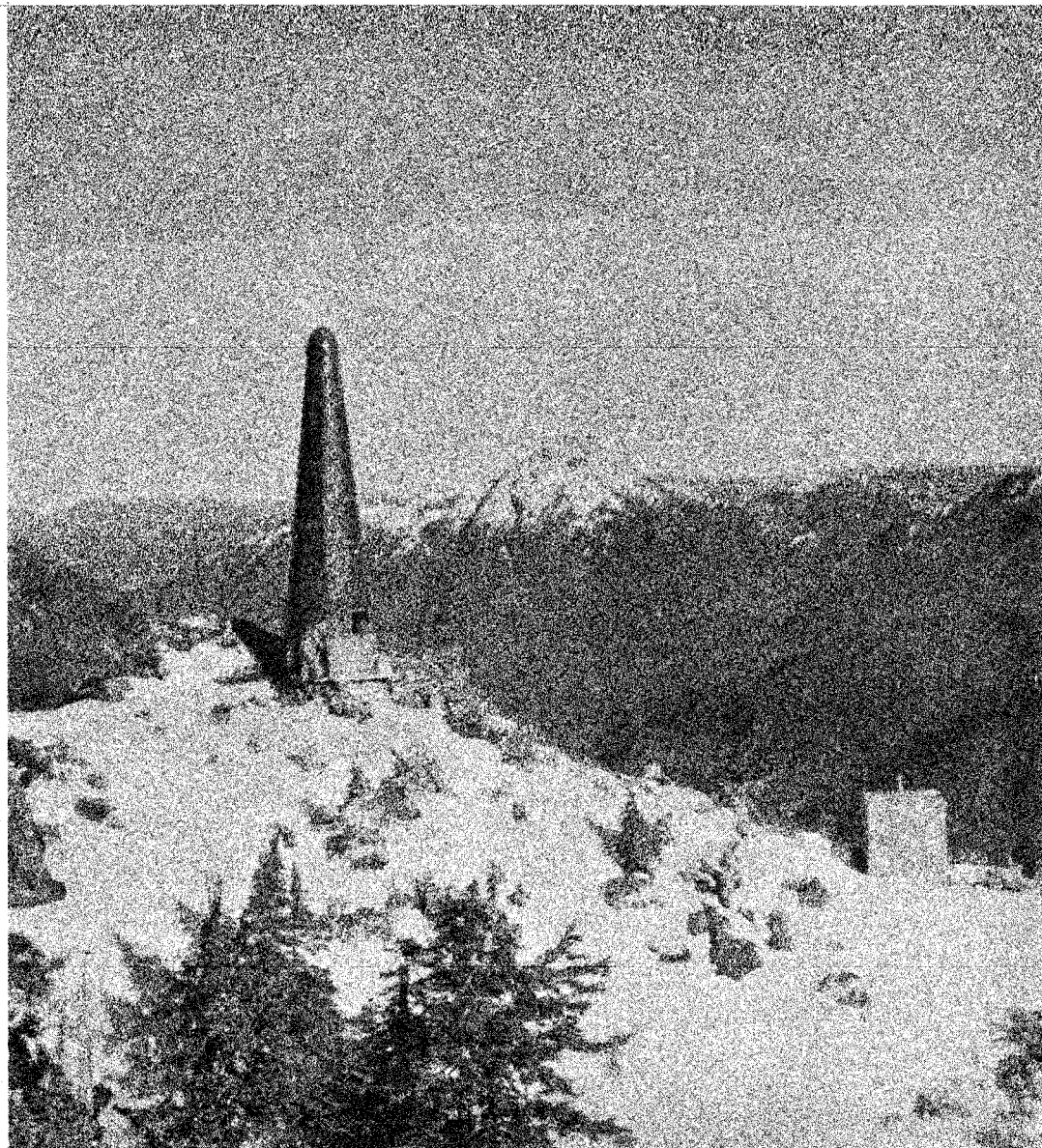


Photo 1. A VHF/UHF radio repeater station on a remote mountain top in British Columbia. Previously used conventional shelter can be seen at the right edge of the photo.

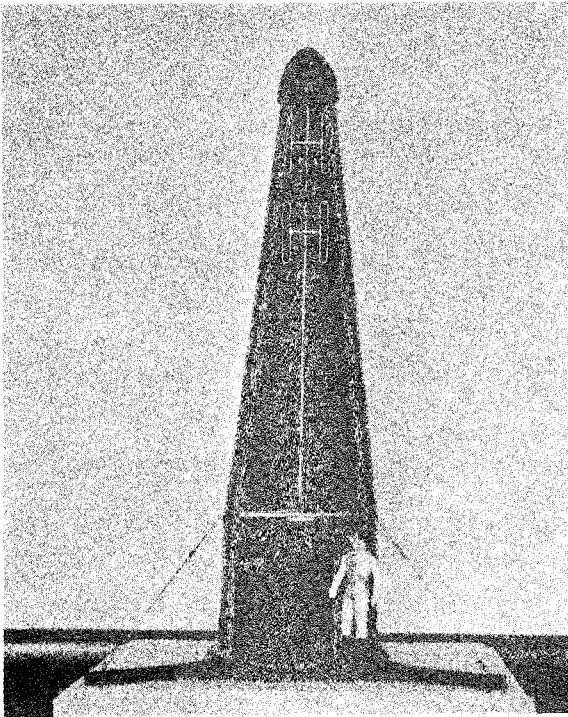


Photo 2. A cut-away model of a repeater station showing the layout of radio equipment.

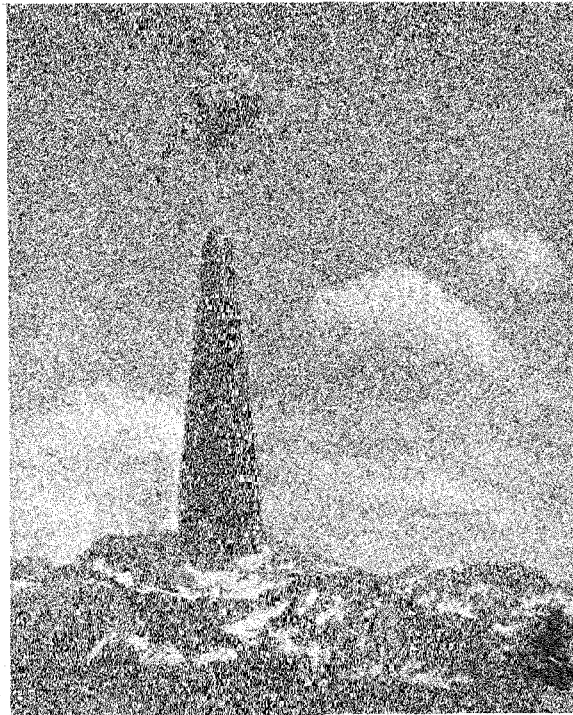


Photo 3. A repeater radome being lifted to a mountain top site by a light helicopter.



Photo 4. A 26 ft. by 7 ft. radome housing VHF and UHF radio equipment for a trunk drop repeater station.

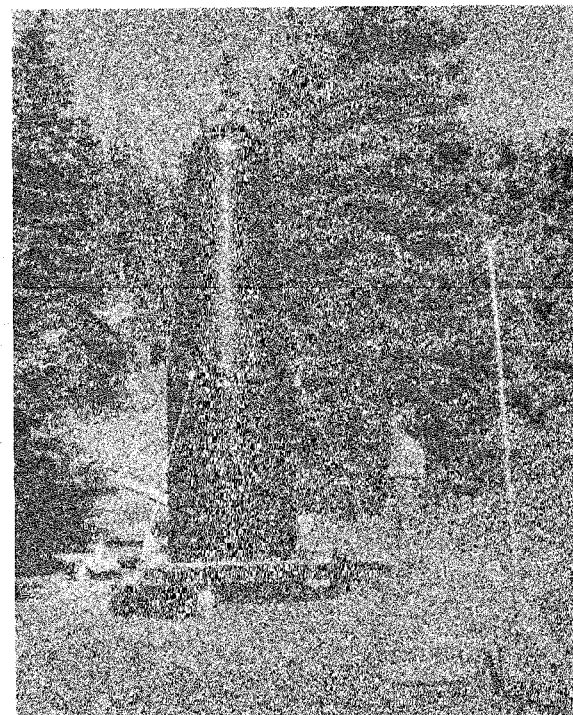


Photo 5. A 15 ft. by 4 ft. radome housing VHF radio equipment and telemetering equipment for a remote work course.