An Unattended Ultra-Short-Wave Radio Telephone System *

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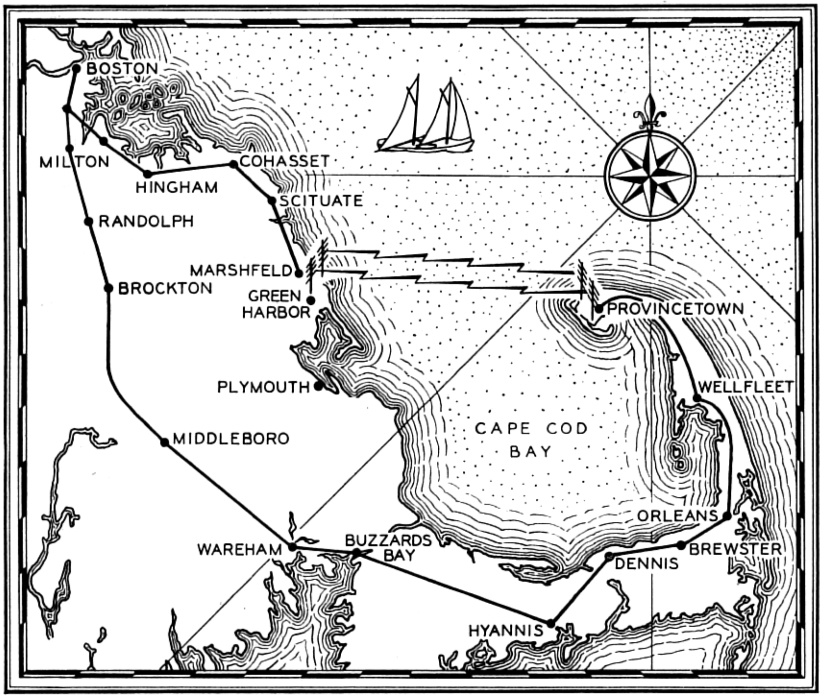
FOR several years attention has been directed by Bell Telephone Laboratories toward determining the characteristics of ultra-high frequencies and their possible application to the telephone plant. This led to the belief that ultra-high-frequency radio might find a useful field as an adjunct to the wire telephone plant in crossing natural barriers where other means might prove difficult or expensive.



Map

In order to make the new facility practicable for use in as many as possible of the situations for which it is technically adapted, it is necessary to keep the total operating costs low. By designing the

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equipment to include certain features over and above the basic requirements, it is possible to reduce to a minimum the attendance necessary to assure continuous operation. Further economies are effected by using equipment capable of continuous operation out-of-doors.

Since ultra-high-frequency radio circuits are normally quite stable and comparatively free from noise, it is possible to omit volume regulation and voice operated devices such as are used on transatlantic circuits at a considerable saving in cost. Under this condition it is necessary, however, to provide a radio transmitter of somewhat higher power capacity than would be required if volume regulation were used, but the cost of this additional power is small compared to the cost of the features required to provide for regulated volume operation.

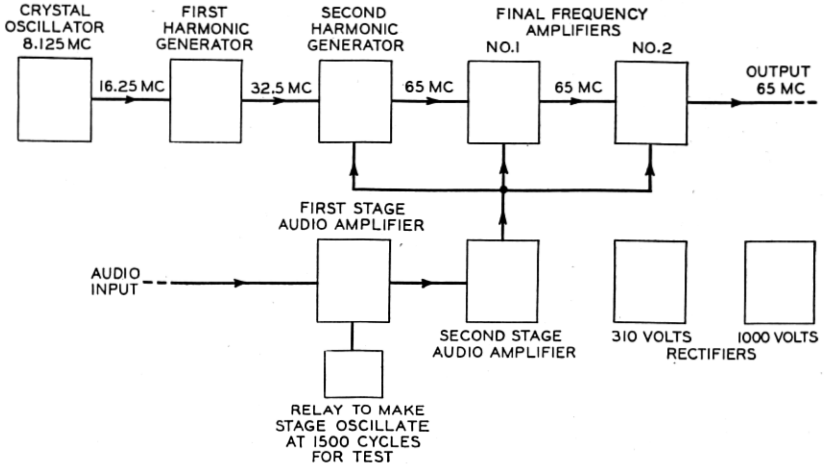

Fig. 1—Block schematic of ultra-short-wave transmitter.

With unattended operation it is desirable that starting and stopping both the transmitter and the receiver be separately controlled from the telephone office. Local testing arrangements should also be provided if possible, to allow the test board operator to determine whether the transmitter and receiver are operating properly.

In order to obtain representative information on the feasibility of operating an ultra-high-frequency telephone circuit on an unattended basis in the telephone plant and to secure a better idea of the mechanical and electrical requirements, equipment was constructed by Bell Telephone Laboratories for such an installation. With the cooperation of the New England Telephone and Telegraph Company this equipment has been used to establish an experimental ultra-short-wave circuit between Green Harbor and Provincetown, Massachusetts, as indicated on the map. Sand dunes near Provincetown, rising about 80 feet, make it possible to secure an optical path across the bay. The

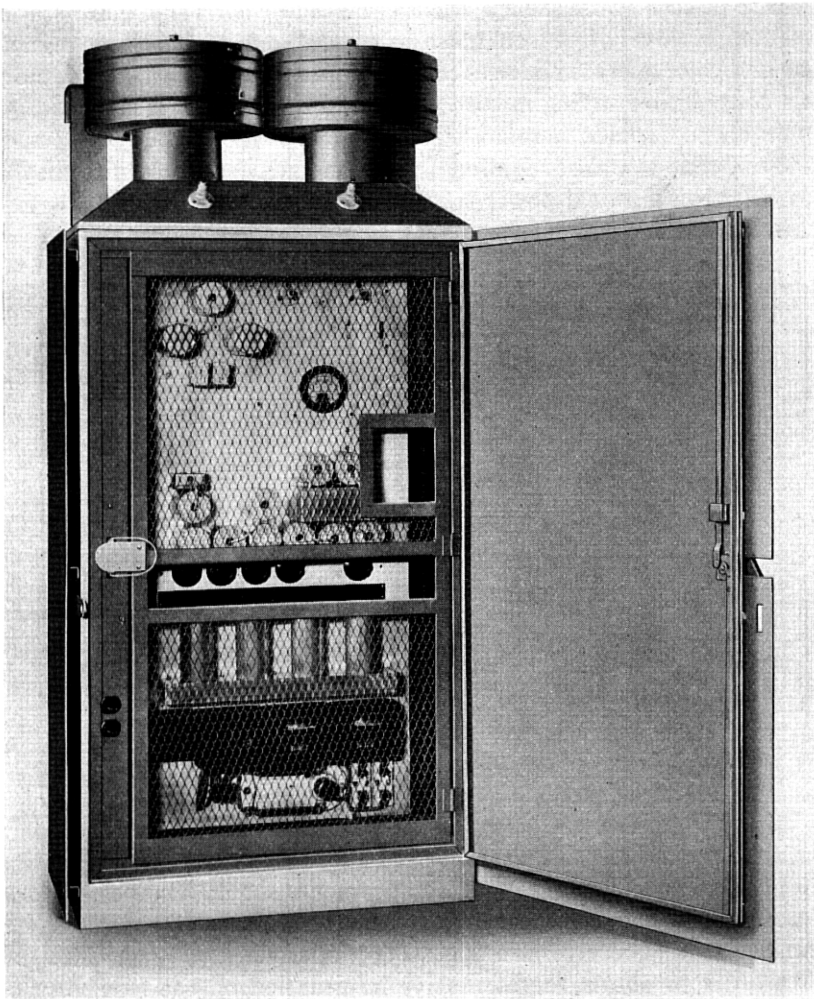

Fig. 2—Ultra-short-wave transmitter mounted in metal container suitable for pole mounting.

radio circuit is extended by wire from Green Harbor to Boston to form a direct Boston-Provincetown toll circuit. It is used as one of a group of terminal circuits and is operated at the normal overall net loss for this type of circuit, namely, 9 decibels. Transmission from Green Harbor to Provincetown is accomplished on a frequency of 65 mc. and in the reverse direction on 63 mc. This does not represent the minimum possible frequency spacing for this equipment, but was a convenient one for the experiment.

At Boston and at Provincetown the circuit appears at a jack in the switchboard beside the jacks of wire toll circuits. As far as the operator is concerned, switching and ringing operations are performed in the same manner as for other similar grade toll circuits and there is nothing to designate that this toll circuit has a radio link. The insertion of a cord into the jack starts the radio transmitter at that end of the circuit.

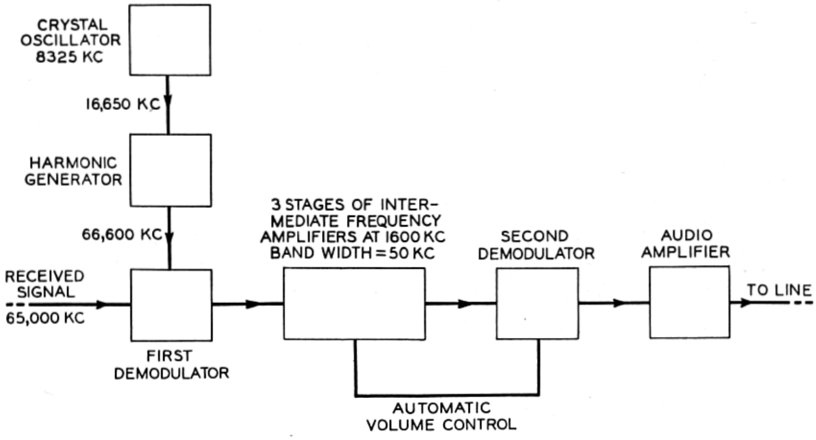

Fig. 3—Block schematic of ultra-short-wave receiver.

The receivers at both ends are kept in constant operation while the circuit is available for traffic but are started and stopped by the operation of a key at the local test board. Ringing is accomplished by sending a 1000-cycle tone interrupted at 20 cycles over the circuit. Privacy equipment similar to that used on the transatlantic short-wave radio channels is installed at the terminal offices.

The transmitters are crystal controlled and are capable of delivering 15 watts of carrier power which can be completely modulated. It was estimated that this would give a reasonably satisfactory circuit. A block schematic of the Green Harbor transmitter is shown in Fig. 1. The Provincetown transmitter is of similar construction.

The receivers are of the double-detection type (see Fig. 3), and to make unattended operation possible and at the same time permit high selectivity at these frequencies, a crystal oscillator is used as the source of beating frequency. A small amount of automatic volume control is provided to compensate for slight variations in received voltage caused by variation in humidity and other factors. The receivers are capable of delivering 0.3 watt of undistorted power to a 600-ohm

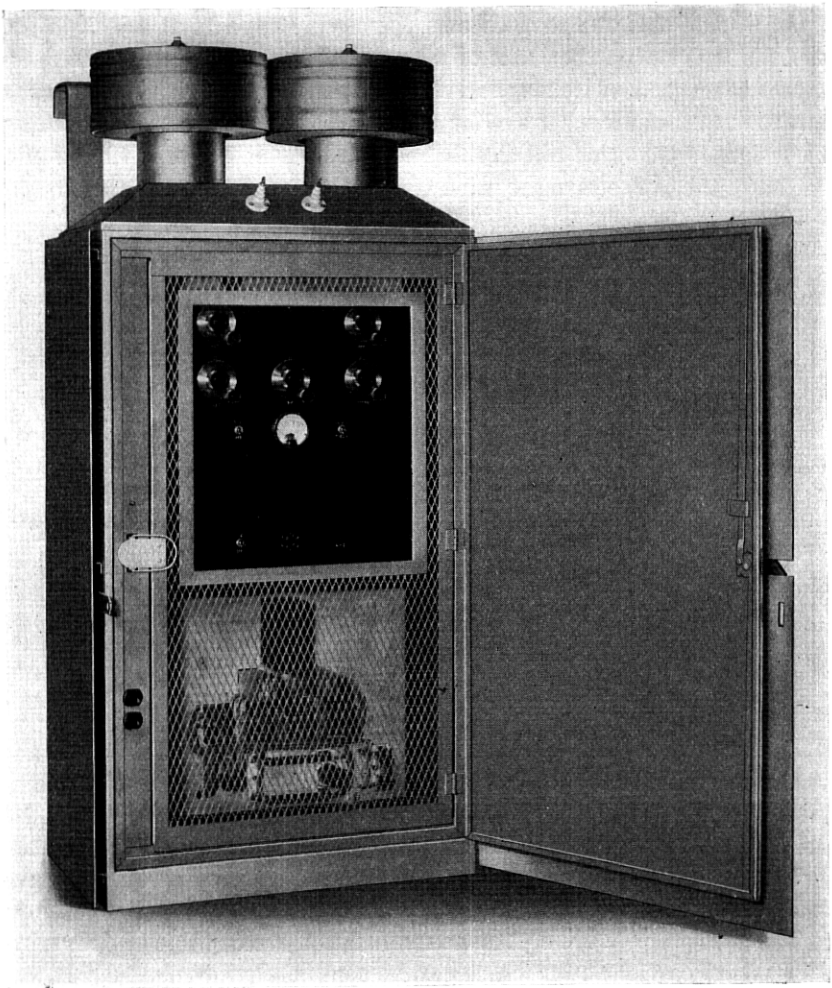

Fig. 4—Ultra-short-wave receiver mounted in metal container suitable for pole mounting.

impedance. This is well in excess of the power required during normal operation.

The transmitting and receiving antennas are identical and each is

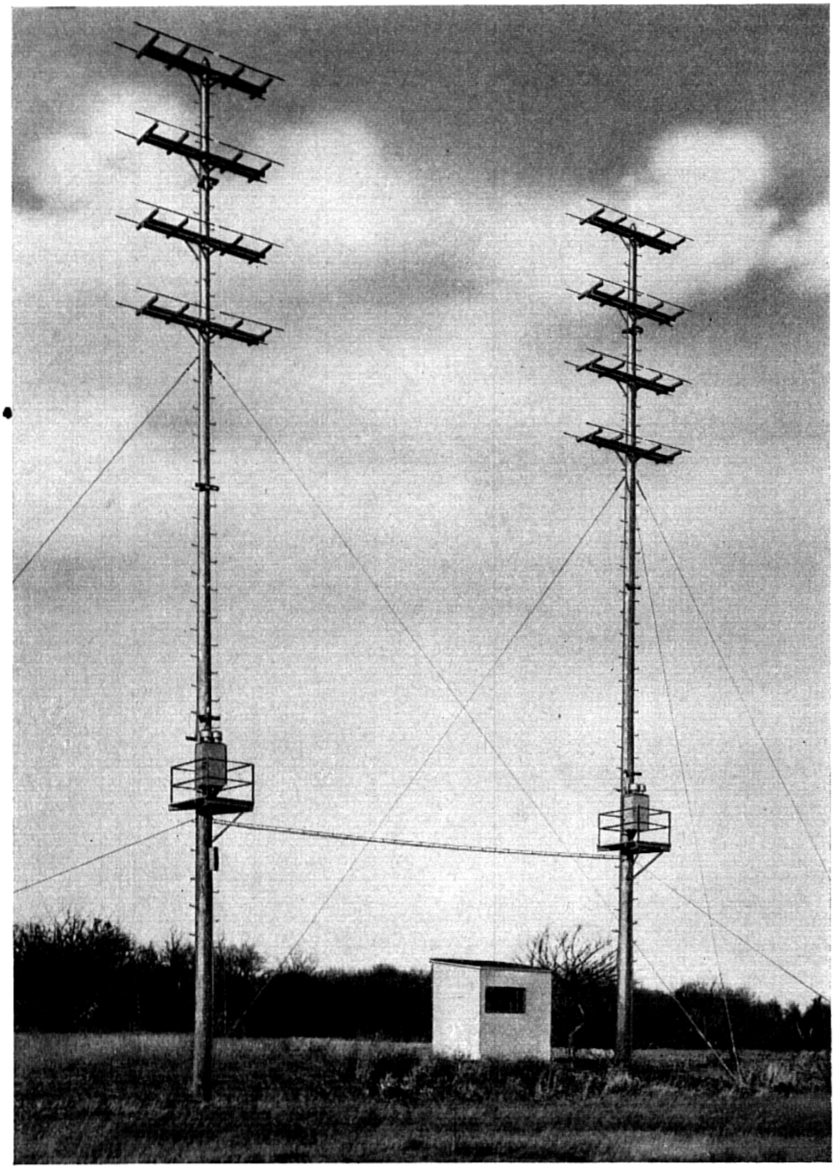

Fig. 5—General view of antennas and pole mounted radio equipment at Green Harbor terminal.

mounted on a single wooden pole about ninety feet high. Horizontal exciter and reflector elements are supported on standard cross-arms. Four pairs of half-wave exciter elements, each comprising two half-wave conductors, are spaced one-half wave-length apart in a vertical

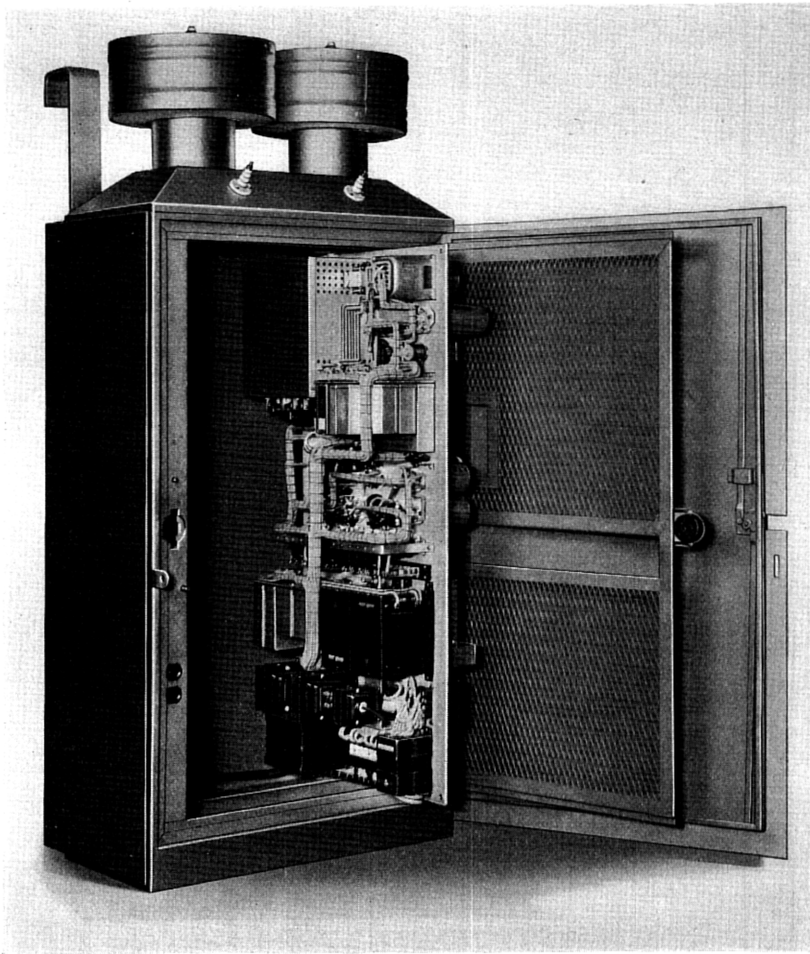

Fig. 6—Open view of ultra-short-wave transmitter.

plane on one side of the pole. Four pairs of half-wave reflector elements are similarly arranged on the opposite side of the pole. The spacing between exciters and reflectors is one-quarter wave-length. These antennas when mounted as shown in Fig. 5, give a gain, measured at the other end of the circuit, of 12 db over a simple half-wave element with the same power input, at the same mean height. This type of antenna was used as it gave the highest gain and directivity which could be conveniently mounted on a single pole. High directivity was desirable not only as a means of increasing the received signal but also to exclude automobile ignition and other noises originating near the receiving stations. The transmitters and receivers are mounted on the poles with their respective antennas.

Daily observations of the circuit loss have not shown variations greater than $\pm$ 4 db from the normal value. Noise from local thunder storms has never prevented the circuit from being utilized in the normal manner. The several months of traffic operation to which the circuit has been subjected have disclosed no important technical difficulties with this type of system. It has been found that the radio apparatus can remain in operation over periods of several weeks without attention or adjustment.