AN/MRC-55 General-Purpose Mobile High-Frequency Communication Equipment

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MILITARY communication set *AN/MRC-55* is a general-purpose high-frequency equipment designed for amplitude-modulated voice, continuous wave, frequency-shift-keyed teleprinter, or simultaneous voice and teleprinter transmission and reception. It is jeep mounted and consists of a nominal 100-watt 2-to-30-megacycle-per-second transmitter, two identical receivers with 2-to-32 megacycle-per-second tuning range, suitable control boxes for local, remote, and relay operation, and all accessories such as microphone, headset, handset, telegraph keys, writing table, loudspeaker, and antennas. The need for extensive operator training has been eliminated by utilizing techniques that automatically perform transmitter-tuning and antenna-loading functions. The radio set is designed for deep-water fording and may be operated from either the 28-volt direct-current supply of the vehicle or from a 115-volt 60-cycle-per-second single-phase source.

Figure 1—At top, *AN/MRC-55* high-frequency radiotelephone and radiotelegraph station mounted in jeep.

As performance specifications for electronic equipment become more severe, generally resulting in more-complex apparatus, the problems of operator training and field maintenance are

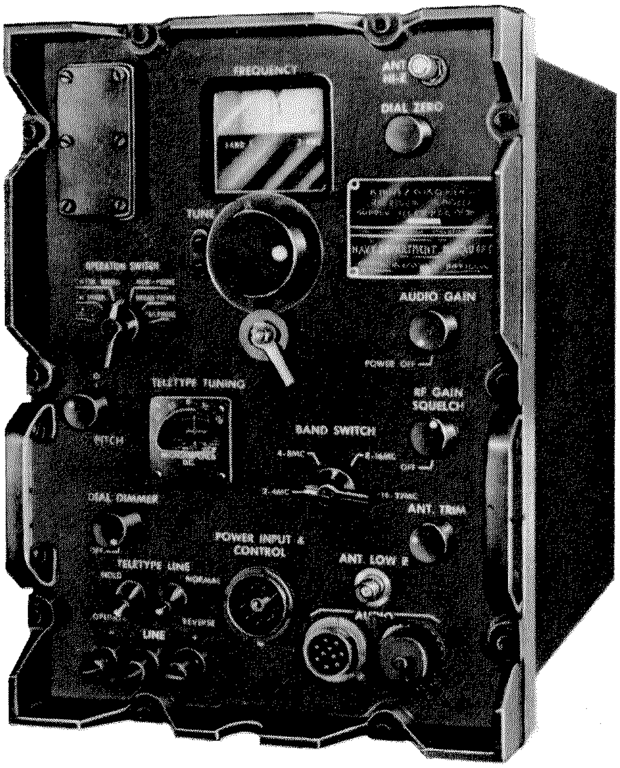

Figure 2—Receiver *R808/GRC-14*.

also multiplied. The *AN/MRC-55* mobile communications set, shown mounted in its carrier vehicle in Figure 1, is designed to minimize these problems and at the same time provide superior communication in the high-frequency range over that obtainable with prior equipments. Operator training time has been reduced to a negligible amount. During evaluation testing, it was determined that untrained personnel could be taught proper operation of the complete equipment in 30 minutes. The automatic tuning features incorporated in the transmitter have made this possible. The techniques used ensure that optimum transmitter power is coupled to the radiating antenna, resulting in superior range. We need no longer be plagued by the problem of improper manual tuning for a maximum indication on a radio-frequency ammeter, which may only mean maximum circulating current in the antenna tuner and minimum radiated power. Modular plug-in chassis construction is employed in both receiver and transmitter to expedite field maintenance. Numerous test points and front-panel monitoring of important transmitter power and signal circuits are provided.

The nomenclature, *AN/MRC-55*, is applied to the complete radio station, including the vehicle, an *M-38A1* modified for deep-water fording along with a special high-output, battery–generator system, *MK-366/MRC-55*. The nomenclature *AN/GRC-14* applies to the radio equipment only as employed for general ground use (fixed installation).

1. *Radio Receiver*

The radio receiver, *R-808/GRC-14*, is shown in Figure 2. It is a high-performance superheterodyne receiver covering a frequency range of 2 to 32 megacycles per second in four bands. Double conversion is used above 8 megacycles per second. It is capable of receiving continuous waves, telephone, and frequency-shift-keyed signals, or the latter two simultaneously. The converter for frequency-shift keying is integral with the receiver, so that the teleprinter loop circuit can be keyed directly. It uses either a high-impedance antenna or a 50-ohm coaxial

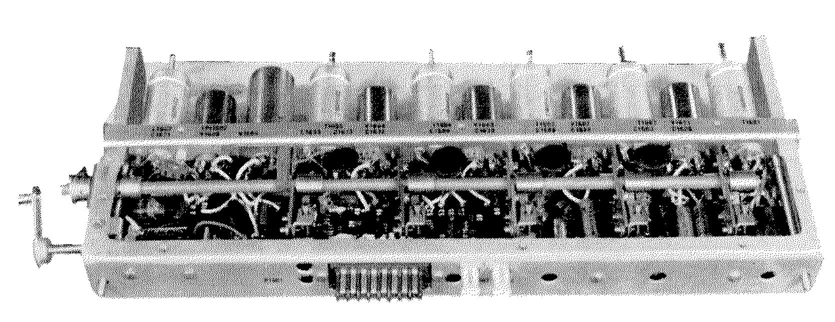

Figure 3—Intermediate-frequency amplifier.

input. Sensitivity is better than 3 microvolts for a 20-decibel signal-plus-noise-to-noise ratio for continuous-wave signals and 5 microvolts for a 10-decibel signal-plus-noise-to-noise ratio with a 30-percent-modulated carrier over the 2-to-8-megacycle-per-second range. Above 8 megacycles per second, the sensitivity becomes 5 microvolts for the continuous-wave case and 8 microvolts for modulated-continuous-wave operation. Two degrees of intermediate-frequency bandwidth

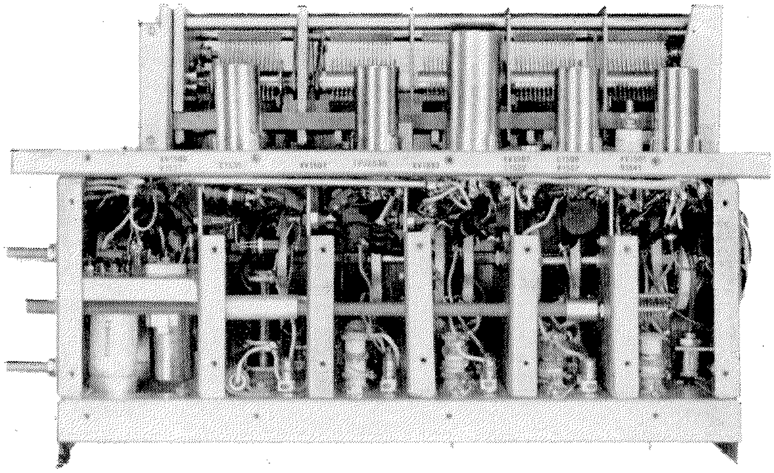

Figure 4—Tuning unit of receiver.

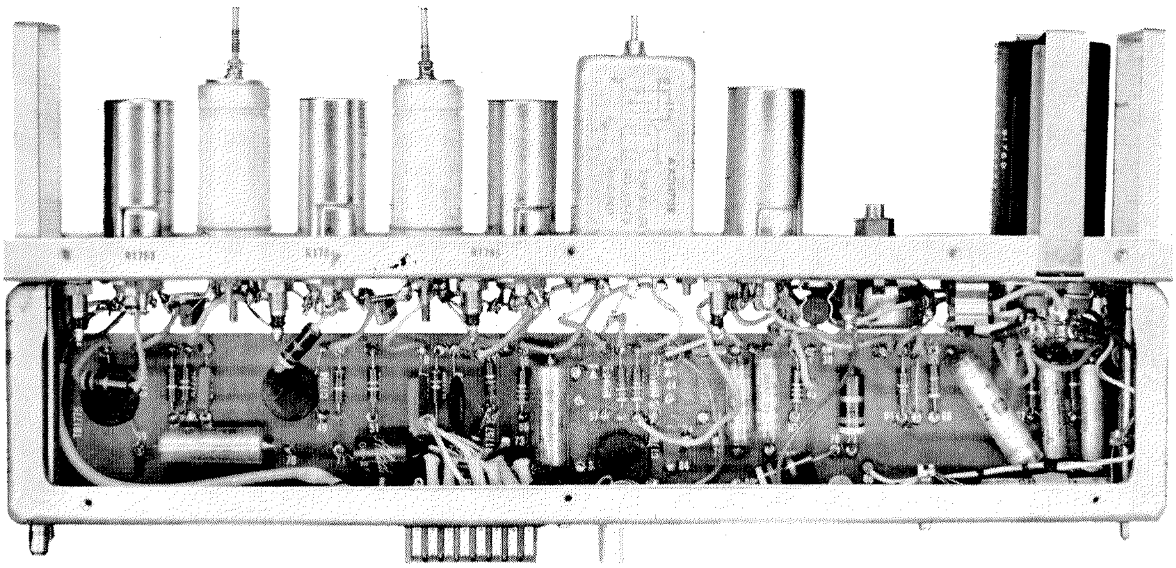

Figure 5—Receiver module for frequency-shift-keying converter.

are provided, namely 3.5 and 7.0 kilocycles per second at 6 decibels down. The 6-to-60-decibel bandwidth ratio is better than 3.5.

The intermediate-frequency amplifier is shown in Figure 3. A combination of printed-circuit and point-to-point wiring is used. Two degrees of audio selectivity are also provided by including a band-pass filter with a 350-cycle-per-second passband centered at 1000 cycles per second. The use of two radio-frequency preselector stages, double conversion above 8 megacycles per second and careful attention to circuit wiring, layout, and filtering have resulted in an intermediate-frequency rejection of better than 60 decibels, an image rejection

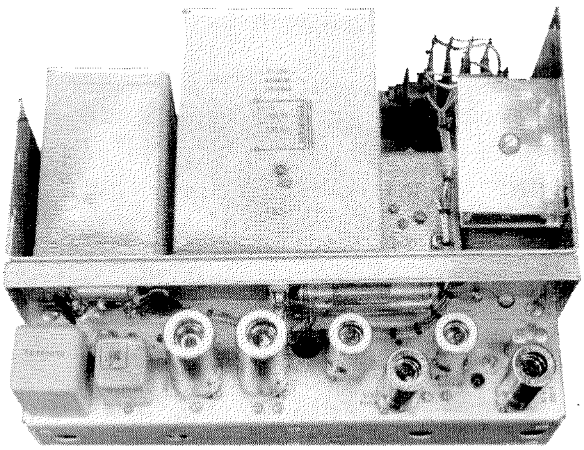

Figure 6—Receiver power supply and amplifier module.

of better than 55 decibels at 2 megacycles per second, reducing to 25 decibels at 32 megacycles per second, and minimum local-oscillator radiation. Figure 4 shows an interior side view of the radio-frequency head. The main tuning scale is approximately 105 inches (267 centimeters) long, allowing incremental scale markings of 2, 5, 10, and 20 kilocycles per second for the four bands from lowest to highest. The scale can be calibrated against a built-in crystal calibrator at check points every 200 kilocycles per second. A high degree of frequency and gain stability is achieved through the use of temperature-compensated components in the high-frequency oscillator, as well as utilization of a transistor-type voltage regulator that supplies all plate and screen voltages and all tube heaters except the frequency-shift-keying converter-unit heaters. Miniature tubes are used in all circuits except the audio output stage, frequency-shift-keying polar-relay drive, and the power supply, which use transistors. Figures 5 and 6 show the frequency-shift-keying converter module and the amplifier and power-supply module, respectively. Each of the two identical receivers uses 23 tubes, 8 transistors, and 6 semiconductor diodes. The receivers are of sealed and gasketed construction and may be submerged during deep-water fording operations.

2. *Radio Transmitter*

Radio transmitter *T-631/GRC-14* is shown in Figure 7. It is rated at a nominal 100 watts of carrier power output over the frequency range of 2 to 30 megacycles per second. It will provide continuous-wave, radiotelephone, frequency-shift-keyed, or simultaneous telephone and frequency-shift-keyed signals. The output circuit normally energizes the jeep whip antenna but may optionally be connected to a 50-ohm coaxial line or to a long wire antenna. Tuning of the radio-frequency amplifier circuits and antenna loading are accomplished automatically. Frequency accuracy and stability are determined by a digitally set synthesizer, which is used to control the frequency of an adjustable-frequency oscillator. The variable-frequency oscillator is manually adjusted to the desired frequency by means of a synchronization indicator that shows when the automatic frequency control is acting on the oscillator frequency. Frequency increments in 100-cycle-per-second steps are available in the stabilized condition. In the event of failure of the synthesizer circuits, the variable-

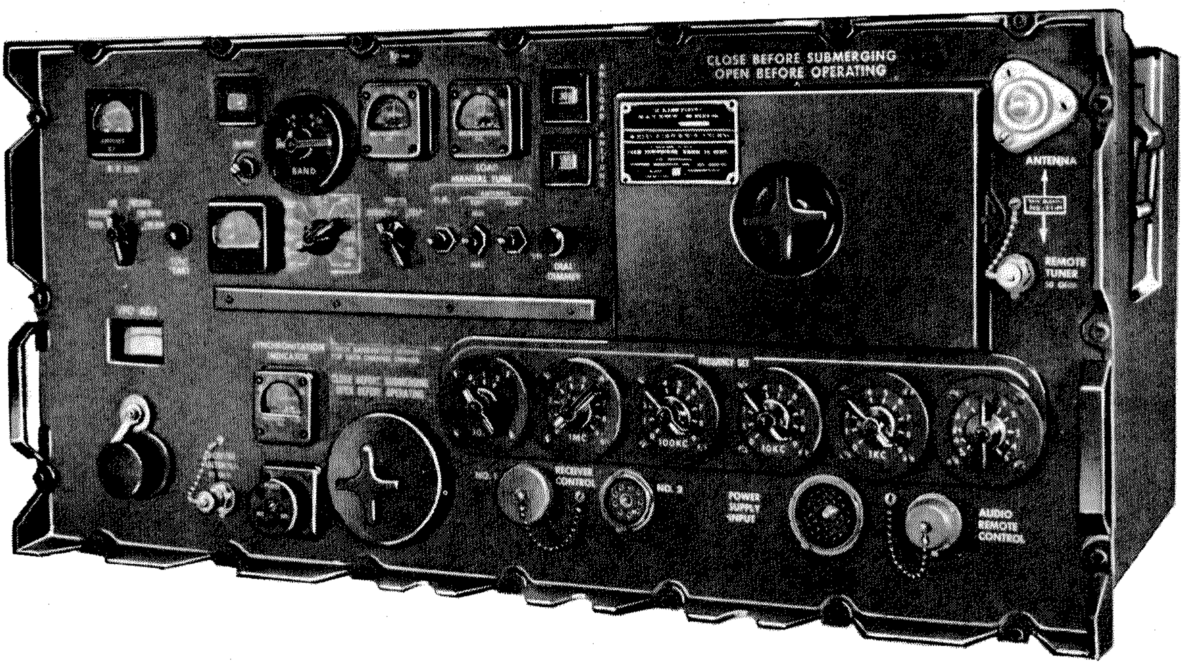

Figure 7—Transmitter *T-631/GRC-14*.

frequency oscillator operates as a standard master oscillator. The output of the variable-frequency oscillator drives the automatically tuned buffer and power amplifier circuits. These, in turn, are connected to the automatically tuned antenna-matching circuit. The transmitter consists of the main chassis and 8 plug-in units. A top view of the transmitter is shown in Figure 8 and the bottom view in Figure 9. All the plug-in units are readily replaceable for rapid field servicing when required. A total of 29 tubes and 21 semiconductor diodes are utilized in the transmitter.

The power output stage utilizes a *4X250F* tetrode. This stage is high-level modulated by two *4X250F* tetrode tubes for telephone operation. An interesting feature of the radio-frequency amplifier–modulator units is the employment of motor-driven adjustable inductances utilizing fine silver ribbon wire for the conductor. The active portion of the inductance is on a low-loss grooved dielectric form, while the inactive portion is wound on a gold-plated short-circuiting drum. Band changing is accomplished by switching fixed capacitors. The use of moulded glass-dielectric capacitors and precision ceramic capacitors resulted in a reduction in size and weight. Space saving was accomplished in the radio-frequency tuner by using a similar adjustable inductance and a vacuum-dielectric adjustable capacitor. These features are clearly shown in Figure 8.

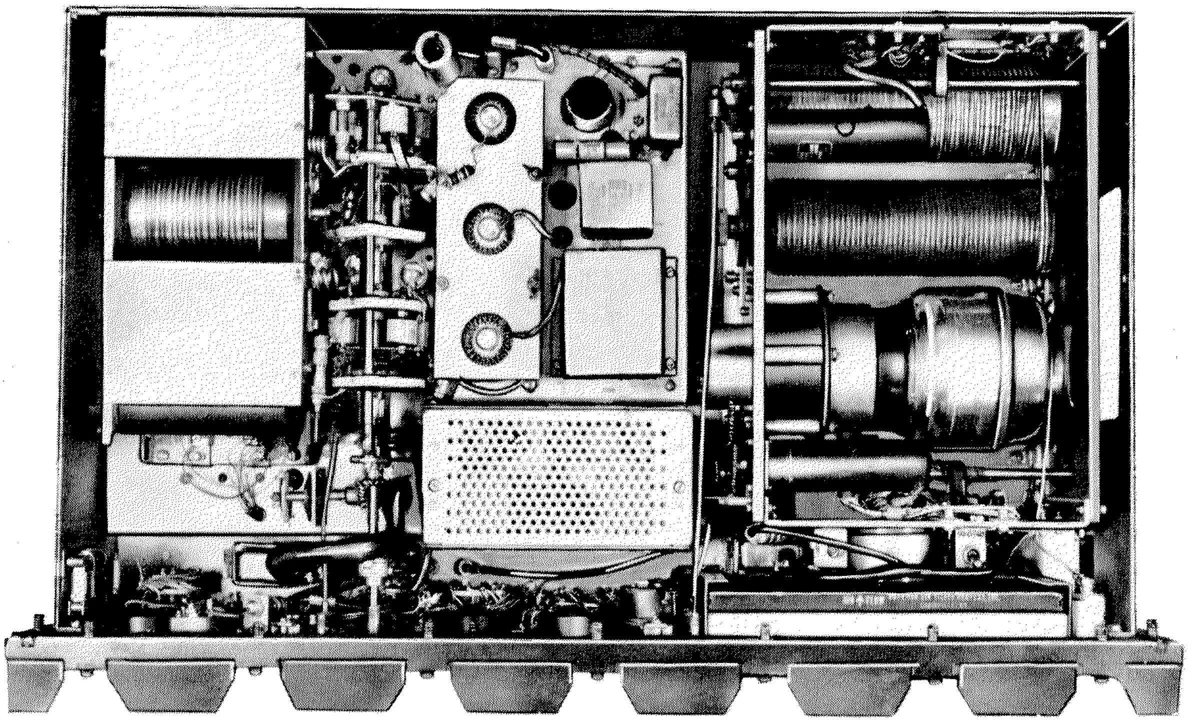

Figure 8—Top deck of transmitter. The radio-frequency tuner is at the right, the audio-frequency amplifier is beneath the perforated plate, and just back of it the anode terminals of the amplifier and modulator tubes may be seen through circular holes in the clamping plate. The circuits for the amplifier tube are at the left.

2.1 Frequency Synthesis

A block diagram of the frequency synthesizer is shown in Figure 10. The variable-frequency oscillator establishes the frequency of transmission. The technique employed to stabilize the transmitted frequency consists of mixing the output frequency from the variable-frequency oscillator with various crystal-controlled frequencies in such a manner that a frequency between 2 and 3 megacycles per second is obtained. This frequency is then compared in a phase detector with a signal of the same frequency obtained by mixing the output of another crystal-controlled oscillator and the output of a high-stability interpolation oscillator. The phase-detector output is a direct voltage that controls the effective capacitive reactance of back-biased diodes that are used to reactance modulate the variable-frequency oscillator and thus control its frequency. Frequency-control action may be best illustrated by a specific example.

In the following discussion, all references are to Figure 10. If we choose an operating frequency of 23.645 300 megacycles per second, the following actions take place. The frequency selector dials are set to read 23.645 300 megacycles per second and the variable-frequency oscillator is adjusted to show synchronization.

The decade switch in Figure 10 is controlled by the tens-of-megacycles-per-second digit of the frequency selector dials. When set at 2, corresponding to 20's of megacycles per second, in addition to making the connections shown, it de-energizes the mixer-selector relay and selects the 20-to-30-megacycle-per-second band of the variable-frequency oscillator.

When the units-of-megacycles-per-second selector dial is set at 3, through paths not shown in the figure, it sets the variable-frequency oscillator to the 23-megacycle-per-second range, selects a 14-megacycle-per-second signal from the fundamental oscillator, and a 35-megacycle-per-second signal from the oscillator–tripler, which two frequencies are applied to mixers A and B, respectively. The oscillator-doubler is inoperative for these settings.

The variable-frequency-oscillator frequency of 23.645 300 megacycles and the 14-megacycle wave from the fundamental oscillator produce in mixer A the sum frequency of 37.645 300 megacycles. This passes through the band-pass filter and via the contacts of the mixer-selector relay to mixer B. The 35-megacycle frequency from the oscillator–tripler passes through the decade switch to mixer B. These two frequencies produce in mixer B a difference frequency of 2.645-300 megacycles per second, which goes through the band-pass filter to the phase detector. In a similar manner, all other operating frequencies are converted to the 2-to-3-megacycle range, except for frequencies in the 2-to-3-megacycle band that pass directly through mixer B to the band-pass filter and the phase detector.

We now proceed to another signal chain that develops the comparison signal from which the

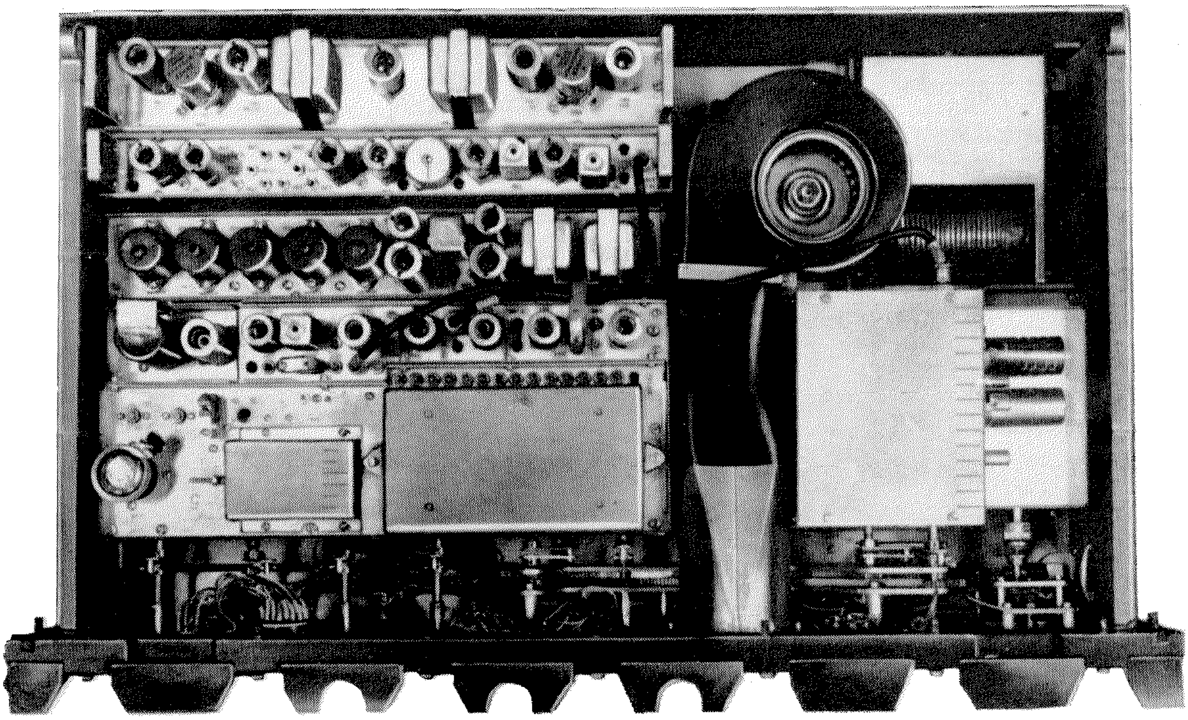

Figure 9—Bottom deck of transmitter. The variable-frequency oscillator is in the box to the right of the blower. The four chassis at the left from the front to the back are the reference-frequency oscillators and mixer keying circuits, mixer-stabilizer, and servocontrol circuits.

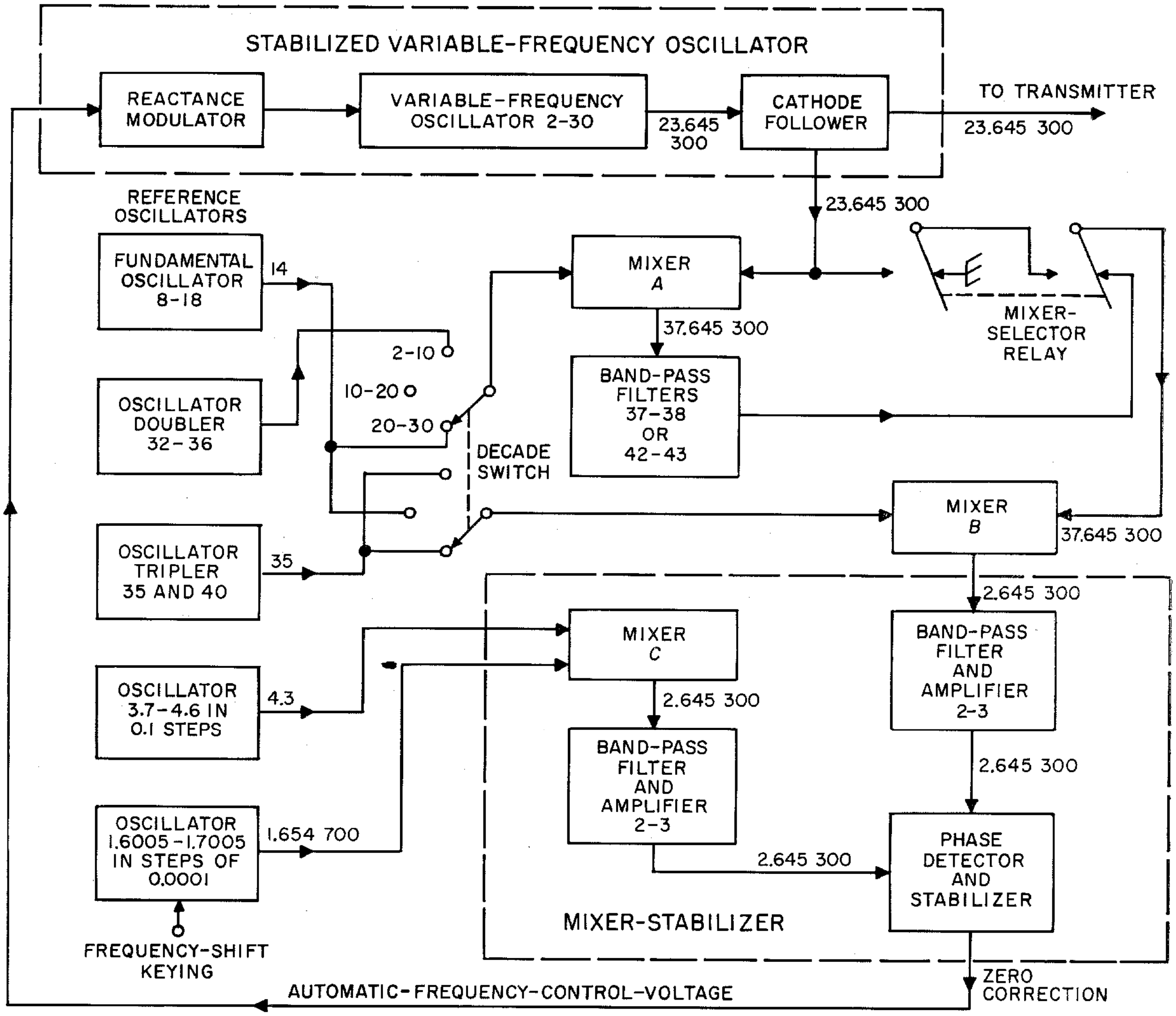

Figure 10—Frequency synthesizer for the transmitter. The numbers are the frequency ranges in megacycles per second.

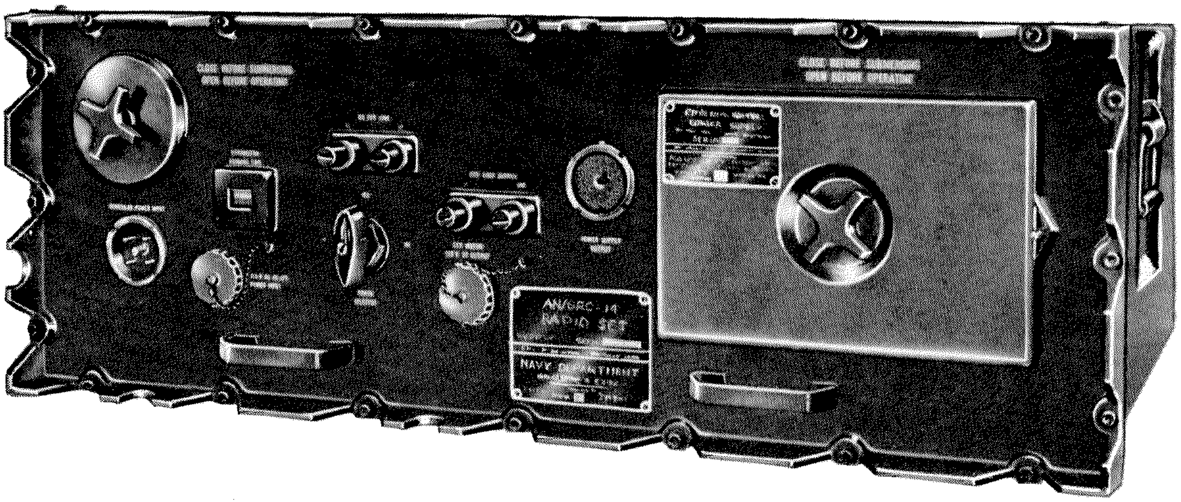

Figure 11—The handwheel-clamped access doors of the power supply are closed for submerging in water and must be opened for ventilation when operating.

phase detector produces any necessary error signal to correct the variable-frequency oscillator.

When the hundreds-of-kilocycles decade dial of the frequency selector is set to 6, a 4.3-megacycle-per-second signal is selected from the oscillator that produces 100-kilocycle-per-second steps between 3.7 and 4.6 megacycles per second. The next three decades of the frequency selector set the frequency of the 1.6005-to-1.7005-megacycle-per-second oscillator, which is adjustable in 100-cycle-per-second steps over its range, to 1.654 700 megacycles per second. In mixer *C*, these two frequencies produce a difference frequency of 2.645 300 megacycles per second, which goes through the band-pass filter to the phase detector.

The phase detector compares the two frequencies that reach it. If they are the same, no output voltage is produced to change the variable-frequency-oscillator. If the two frequencies are not the same, an error voltage is produced by the phase detector of such polarity and amplitude as will act on the reactance modulator to adjust the frequency of the variable-frequency oscillator to make the two frequencies impressed on the phase detector the same.

The precision of the output frequency depends on the accuracy of the crystal and 1.6005-to-1.7005-megacycle-per-second reference oscillators. In the event of failure of any of the synthesizer units, the transmitter will continue to operate under control of the variable-frequency oscillator but without benefit of frequency stabilization.

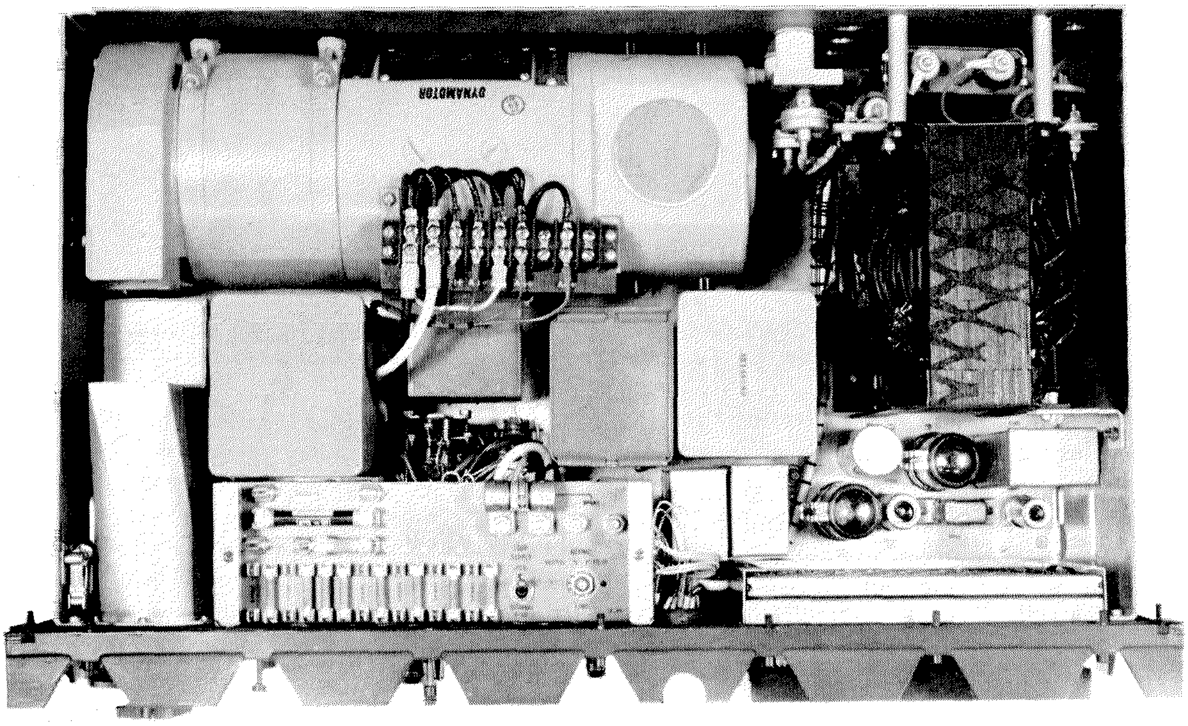

Figure 12—The transformer and silicon rectifiers in the upper right corner permit the dynamotor of this power supply to be operated from alternating current.

2.2 Power Supply

The power supply designated *PP-1711/GRC-14* is shown in Figures 11 and 12, furnishes all necessary voltages for transmitter operation, as well as power for the teleprinter and the associated loop circuit. The unit is designed to operate from a primary power source of either 28 volts at 40 amperes of direct current or from a 110-volt single-phase 60-cycle-per-second alternating-current supply at 1.6 kilovolt–amperes.

The main power switch selects the type of power source. In direct-current operation, the dynamotor is supplied directly from the primary power source. For alternating-current operation, primary power goes to the step-down transformer shown in the upper right-hand corner of Figure 12 and then to the two silicon rectifiers immediately adjacent. These rectifiers are connected for full-wave operation and are mounted on a heavy heat sink cooled by the input air stream to the dynamotor. The unfiltered direct current supplies the dynamotor input. The output voltages of the dynamotor are filtered. The voltage-sensitive circuits are operated from an intermediate value of voltage for which regulation is provided.

The receiver power supplies are self-contained. They also operate from either 28 volts direct current or 110-volt, 60-cycle-per-second, single-phase alternating current, drawing about 80 watts in each case.

2.3 Accessories

The control group, *OA-1444/GRC*, is shown in Figure 13 and consists of control box *C-2171/GRC-14* installed at the transmitter and control box *C-2172/GRC-14* located in the field. These units provide for remote operation over a mile (1.6 kilometers) of two-wire line and also supply standard two-way telephone and ringing facilities so that the local operator at the jeep can talk with the remote operator. The transmitter can be turned on and off and modulated with microphone or keying signals from the remote point.

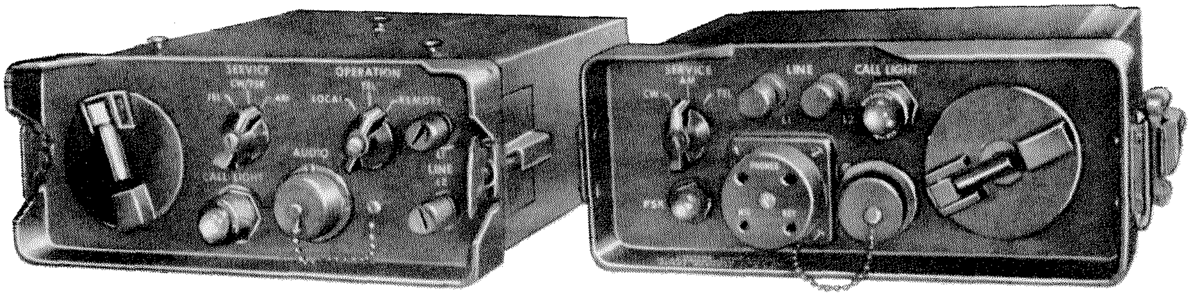

Figure 13—At left is control unit *C-2171/GRC-14* installed at the transmitter and at the right is *C-2172/GRC-14*, which may be at the end of a mile (1.6 kilometers) of line, for remote operation.

Included in the accessories are all necessary microphones, handsets, headsets, and special wrenches. An operator's writing table is supplied.

In addition to the two whip antennas, normally installed on the jeep, a long wire antenna is also provided.