Figure 3 — Part of transmitter room of the VOA Philippines Relay Station showing Machlett ML-5682's in Continental 1 Mw medium-wave transmitter which broadcasts to Asia on 1140 kc.

the system. In the case of international broadcasting, the system begins at the microphone and ends in the receiver of the listener. In the technical development of the VOA, the "systems concept" — that of considering the performance of the system as a whole — has been of paramount importance.

Relay Stations

The development of the VOA facilities system centers upon the use of overseas relay stations, at locations where it is possible to take maximum advantage of favorable radio propagation conditions, to overcome the problems facing direct shortwave broadcasting from the United States.

While the transmission paths passing through the auroral zones are heavily distorted and absorbed, paths that do not pass near the auroral zones are not affected by this phenomenon. In Figure 1, for example, the circuit from New York to Tangier, Morocco, does not pass near the auroral zones, and it is therefore possible to maintain a reliable program service from the United States to Tangier by shortwave.

The effects of the auroral zone on circuits from Tangier are indicated in Figure 2. It can be seen, by comparison with Figure 1, that the very areas that are shielded from the United States can be reached without difficulty from Tangier. Therefore, programs transmitted to Tangier can be simultaneously relayed from Tangier directly into European or Near and Middle Eastern target areas— areas that cannot be reached effectively directly from the United States. By the use of strategically located relay stations, the auroral zone can be by-passed and technically effective transmissions can be delivered to target areas that are normally shielded from direct transmission from the United States.

Auroral zone by-passes to other areas of the world can be achieved by locating relay stations in, for example, Hawaii and the Philippines. Both the fundamental problems of distance and auroral zone absorption can be solved by this relay station concept. Relay stations in such locations can receive shortwave transmissions directly from the United States with the least possible effects from auroral zone absorption. After receiving the transmissions, the relay station can boost them in strength and simultaneously relay them directly into selected target areas on the broadcast bands that are popular in the areas and lie within the range of most of the available receivers.

Based upon this concept, VOA relay stations have been established at various locations throughout the world. Each station is a complete self-contained installation with its own diesel-power plant, small studio complement, receiving station for program reception, high-power short, medium and longwave transmitting facilities, and point-to-point radio teletype communications facilities.

The relay stations are integrated into a single system so that they can be fed programs directly from the United

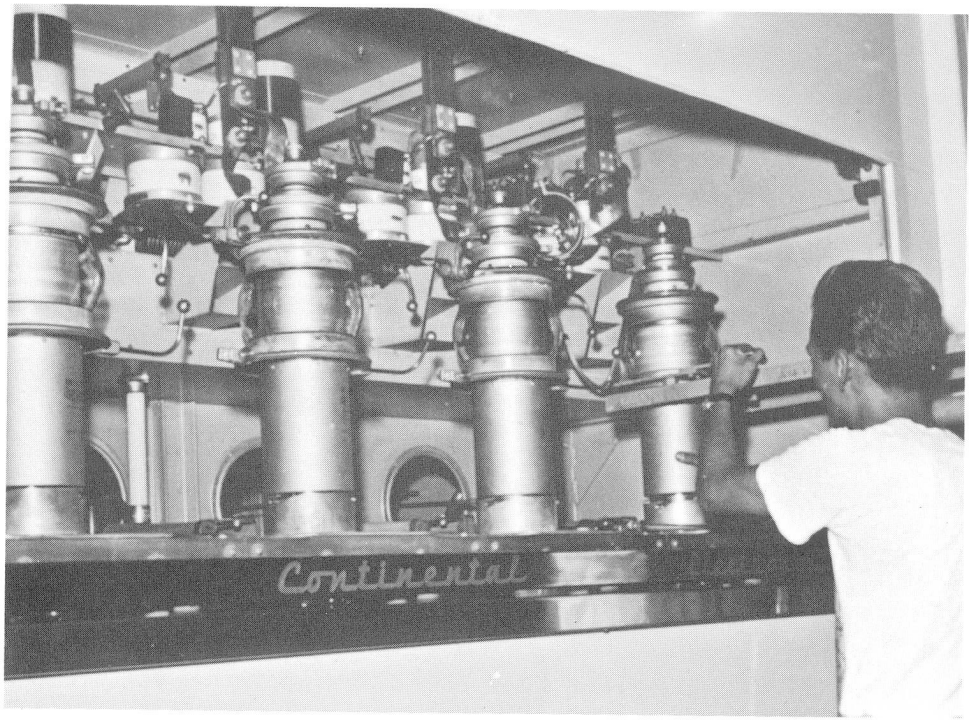

Figure 4 — Technician at Philippines Relay Station checks Machlett ML-5682 tubes in power amplifier of one megawatt transmitter.

States, or from another relay station.

The overseas relay system of the VOA consists of the following:

1. *Tangier, Morocco:* This station is used primarily as VOA's main gateway to Europe, North Africa and the Near and Middle East. At Tangier, the major facilities consist of ten shortwave transmitters ranging in power from 35 to 100 kilowatts. Twenty-five rhombic antennas are available for beaming programs to the various target areas. Figures 3 and 4 are interior and exterior views of the Tangier Relay Station.
2. *Munich, Germany:* This location is close enough to the Central European target areas so that the medium wave band can be used, as well as shortwave. The station consists of four shortwave transmitters ranging in power from 75 to 100 kilowatts, and several lower power transmitters. A 300 kilowatt medium-wave transmitter operates on a frequency of 1196 kc. Seventeen shortwave antennas are available for coverage of Europe, the Eurasian areas of the Soviet Union, Near and Middle East, and parts of Africa. The medium-wave antenna is a 4 element array providing four separate patterns each beamed towards a desired European target area. This antenna system is designed for sky-wave radiation out to about 500 miles from Munich. During the post war years and when Soviet jamming was at its height, the Agency built and established a very high powered (megawatt) long wave transmitter at Munich which operated from 1953-1964 on 173 kc. The antenna consisted of a single top loaded tower over 900 ft. high designed for omnidirectional radiation to provide coverage of Central Europe. In February of 1964, use of this transmitter was suspended when the Russians ended their jamming activity. The plant is currently in reserve in case its mighty signal suddenly becomes needed again.
3. *Thessaloniki, Greece:* This relay station was engineered to take advantage of its proximity to the Balkan target areas. The station consists of four 35 kilowatt shortwave transmitters, and a 50 kilowatt medium-wave transmitter operating on a frequency of 791 kc. Twelve shortwave antennas are available for coverage of the Balkans, the western Soviet Union, East Europe, the Near and Middle East. The medium-wave antenna consists of a 2 element directional array providing a reversible cardioid pattern with one beam centered to provide sky-wave coverage of the Balkans and the other to provide coverage of Greece.
4. *Rhodes, Greece:* VOA's station at Rhodes is used primarily for covering adjacent areas of the eastern Mediterranean. A 150 kilowatt medium-wave transmitter beams broadcasts to this area, primarily in the Arabic language, for approximately nine hours a day on a frequency of 1259 kc. Two 50 kilowatt shortwave

transmitters reinforce the medium-wave coverage. The medium-wave antenna consists of a three-tower array, producing a coverage pattern in the eastern Mediterranean similar in shape to a cardioid. Six shortwave antennas are available for beaming shortwave transmissions into the intended coverage area. From late 1951 and until May, 1964, VOA transmitting facilities at Rhodes were housed aboard a docked vessel, the U.S. Coast Guard's Courier. Since May, 1964, new land-based facilities have replaced those previously housed aboard the Courier.

5. *Philippines:* VOA maintains transmitting facilities near Manila and San Fernando on the Island of Luzon. These facilities consist of nine shortwave transmitters ranging in power from 35 to 100 kilowatts, a 50 kilowatt medium-wave transmitter operating on 920 kc, and a 1,000 kilowatt medium-wave transmitter operating on 1140 kc. There of the shortwave transmitters are transportable, and have been installed recently to provide increased VOA coverage of Southeast Asia. Twenty-five rhombic antennas are available for beaming shortwave broadcasts over an arc extending from Korea to India. The 50 kilowatt medium-wave transmitter uses a six-tower array for sky-wave coverage of the Philippines and adjacent areas of Southeast Asia, while the megawatt transmitter uses a four-tower array which produces three separate beams directed towards Southeast Asia and parts of China. This antenna system increases the effective power of sky-wave radiation to 3,500 kilowatts in certain directions.
6. *Okinawa:* VOA's Okinawa installation completes the Far Eastern coverage by beaming short- and medium-wave broadcasts to northern and central Asiatic areas. This station consists of three shortwave transmitters ranging in power from 35 to 100 kilowatts, and a 1,000 kilowatt medium-wave transmitter operating on 1178 kc. Six rhombic antennas direct shortwave transmissions to Siberia, the Far East, China and Central Asia. The medium-wave antenna consists of a six element array producing two beams directed towards China, Manchuria, Korea and Soviet Far East. In addition, two low-powered shortwave transmitters are used to augment the coverage.
7. *Colombo, Ceylon:* This installation, operated for VOA by Radio Ceylon in accordance with an agreement between the Governments of the U. S. and Ceylon, is intended primarily for coverage of India and Pakistan. The station consists of three 35 kilowatt shortwave transmitters. A large number of curtain arrays are available for beaming broadcasts to India, Pakistan, and adjacent areas.
8. *Woofferton, England:* Six 250 kilowatt and two 50 kw shortwave transmitters, operated for VOA by the British Broadcasting Corporation, on a contractual basis, beam Voice broadcasts to Europe, Africa and the Near and Middle East. Thirty-five high-gain curtain antennas are available for directing these transmissions to their target areas.
9. *Honolulu, Hawaii:* This station, located in the nation's newest state, serves as an auroral by-pass to the Far East and Southeast Asia. It consists of two 100 kilowatt shortwave transmitters and seven rhombic transmitting antennas.
10. *Monrovia, Liberia:* VOA's installation near Monrovia consists of six 250 kilowatt and two 50 kilowatt shortwave transmitters intended for coverage of the entire African continent. Twenty-nine high-gain transmitting antennas are available to beam VOA broadcasts over a wide arc from the Mediterranean to the South Indian Ocean. This installation came into full operation during 1964.

Modernization Needs Stimulate New Facilities

The overseas system of the VOA, consisting of fifty-nine high-power transmitters, effectively by-passes the auroral zone and bridges the vast distances between the U.S. and the target areas, enabling VOA to reach listeners with competitively strong signals in the broadcast bands most popular in the areas.

Still the network was not complete. Changing economic and domestic political factors had their effects. As a result of necessary economies in 1953, the Agency cut back some of its stateside facilities, eliminating the most obsolete and least efficient (high cost per KWH on the Air) elements. During this period the domestic system was reduced by 12 transmitters and operations were carried on by the remaining thirty.

Meanwhile the Soviet jamming effort, begun by them in 1948, continued and intensified. At the same time, the Russians and their satellites together with the United Arab Republic and the Chinese greatly increased their shortwave operations with the latter two passing both the BBC and the VOA to take over 2nd or 3rd place (Russia was and is first) in total number of program hours broadcast daily.

Many newly emerging countries and developing nations began, or increased their shortwave broadcasting, too. For these countries, shortwave radio provides an effective, simple and relatively inexpensive means of mass communication. Even the Soviet Union depends to a great extent on shortwave radio for keeping its people in the hinterlands informed.

The increased availability of transistorized radio receivers at steadily lowering costs also played an important part in the upsurge in the popularity of shortwave broadcasting. With receivers independent of power lines and capable of being operated for months on a few cheap batteries, radio could and did penetrate into rural and under-developed areas, opening up vast new audiences, both for the Voice