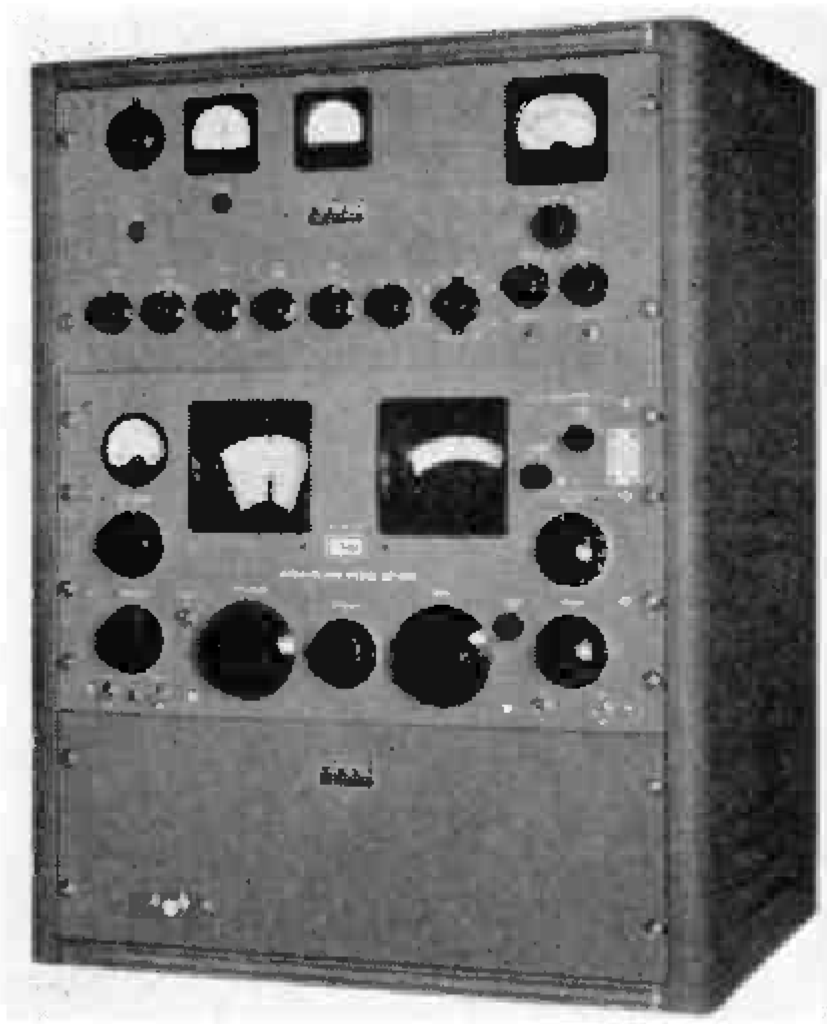


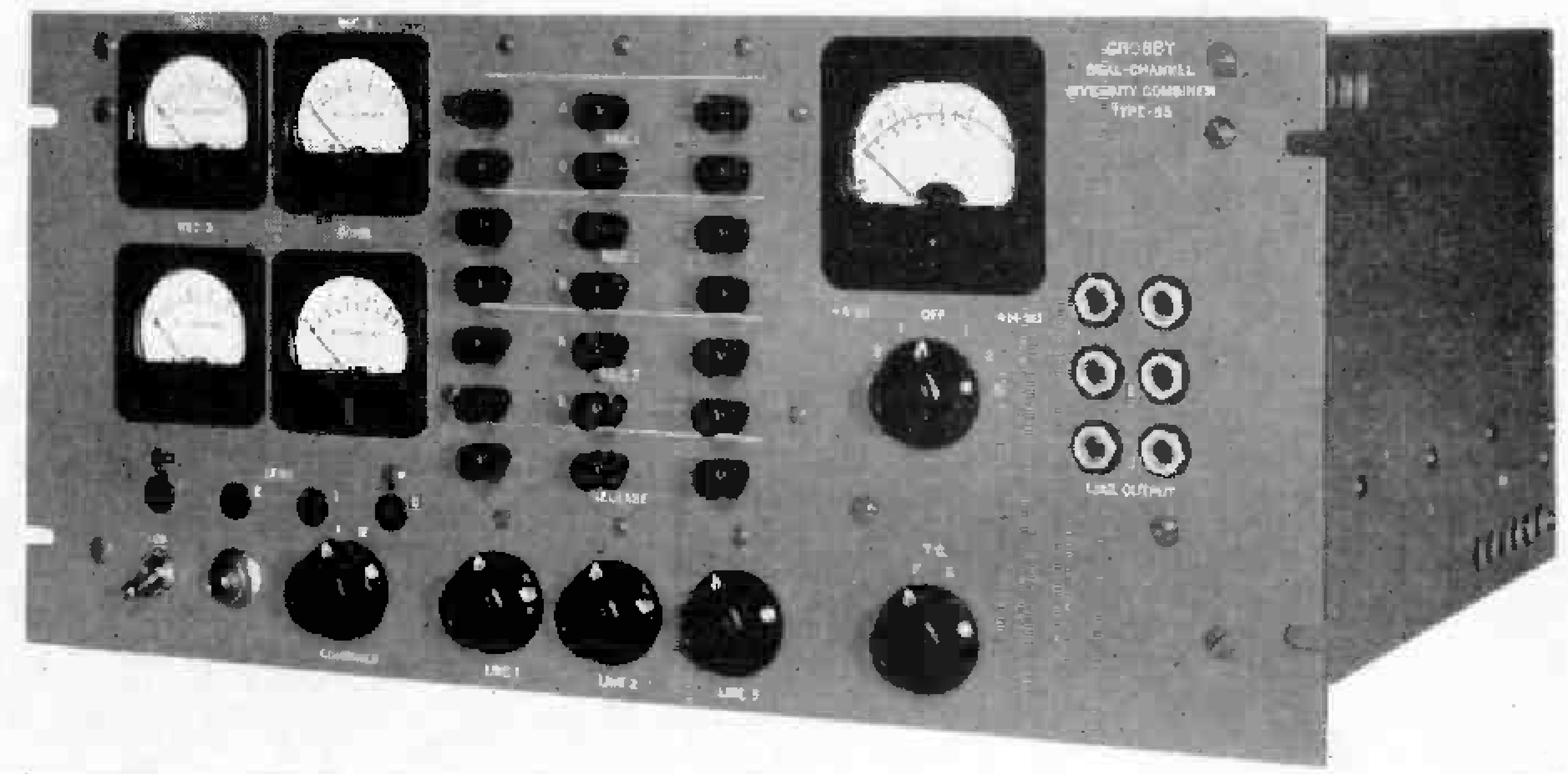


FIG. 2, LEFT: SINGLE-SIDEBAND RECEIVING UNIT WITH POWER SUPPLY. FIG. 6. DIVERSITY COMBINER

Long-Range Communication With

Single-Sideband Diversity Units

TRANSOCEANIC COMMUNICATION CAN BE ACCOMPLISHED DEPENDABLY WITH SINGLE-SIDEBAND DIVERSITY EQUIPMENT — *By* MURRAY G. CROSBY*

ONE of the heaviest long-range communication traffic loads in history occurred during the time of the recent coronation ceremonies in England. Wide use was made of single-sideband equipment, which performed very creditably. Dependable transoceanic reception of standard traffic and photo transmissions was achieved with Crosby triple-diversity single-sideband systems, used by RCA Communications and Press Wireless. This relatively new equipment is described in the following pages.

Advantages of Single-Sideband: A primary reason for the increased use of single-sideband systems is that they yield an important saving in frequency bandwith requirements. This is of great importance because of the rapid growth in international radio communication, which is worsening the already-severe congestion in the short-wave channels.

In addition to the basic advantage of economical frequency utilization, single-sideband systems permit a 9-db effective power gain as compared with double-sideband AM systems. This improvement factor is of considerable significance, particularly in multi-channel communication circuits and in international broadcast services where quality of signal must be preserved in order to meet basic performance requirements.

Single-sideband receiving techniques have significant value in eliminating certain types of interference even when employed with double-sideband transmission systems. A single-sideband receiver can operate in the presence of interference which may fall within the range of one sideband, but not in the range of the other. Sideband selection in such a case can get rid of the interference completely. This, of course, is a real advantage in view of the present severe band overcrowding and international jamming. At the present time, as a receiver is tuned to various signals in the HF frequency range, it is a very rare occurrence to find one signal free from interference on both sidebands, and which could not be improved by using one sideband alone. Thus, there is an obvious advantage in the use of single-sideband receivers in any communication system, even though the receiver may not be utilized in receiving signals transmitted by the single-sideband method.

Single-Sideband Adaptor: In a single-sideband system, a conventional short-wave communications receiver is employed to select and amplify the desired radio-frequency carrier and its modulation components. Fig. 1 is a block diagram of the adaptor for converting such a receiver to single-sideband operation; a view of the combined receiver (in this case, a Hammarlund SP-600JX) and adaptor is given in Fig. 2.

By means of a coaxial-cable connection with the IF output circuit of the receiver the selected carrier signal, at intermediate frequency, is fed to the converter of the adapter. Here the carrier is heterodyned with a second signal from a high-frequency oscillator, under precise automatic frequency

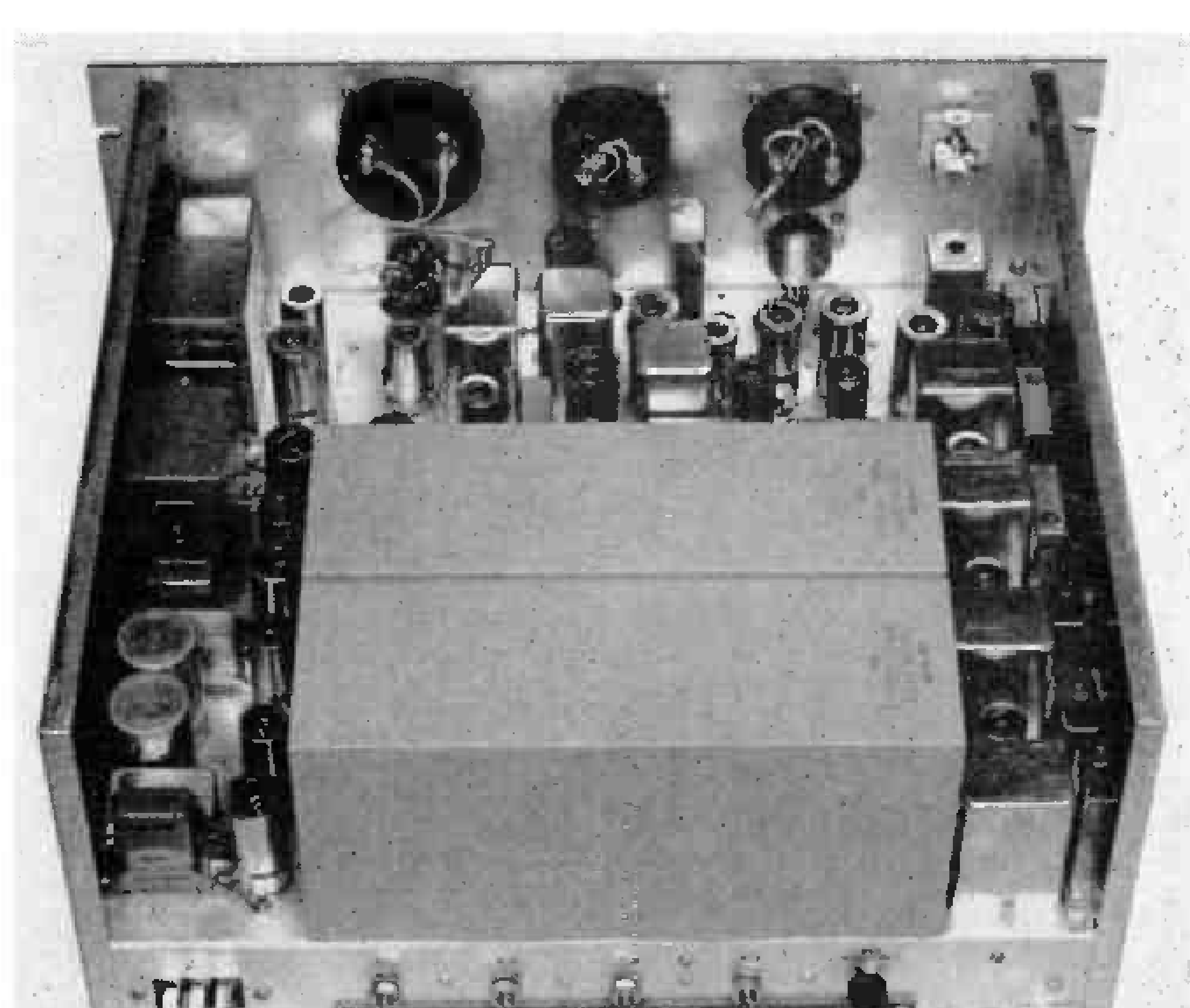
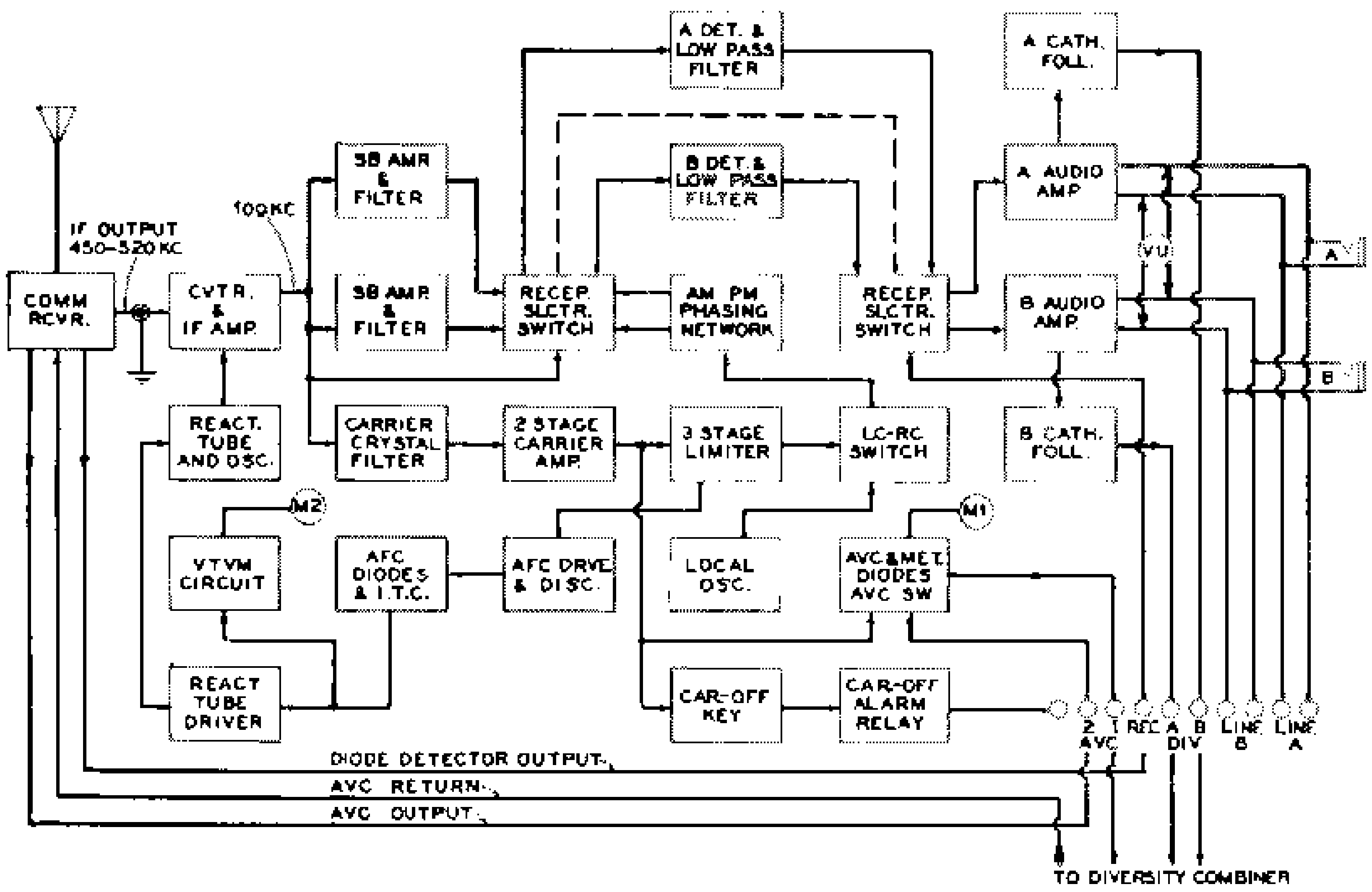
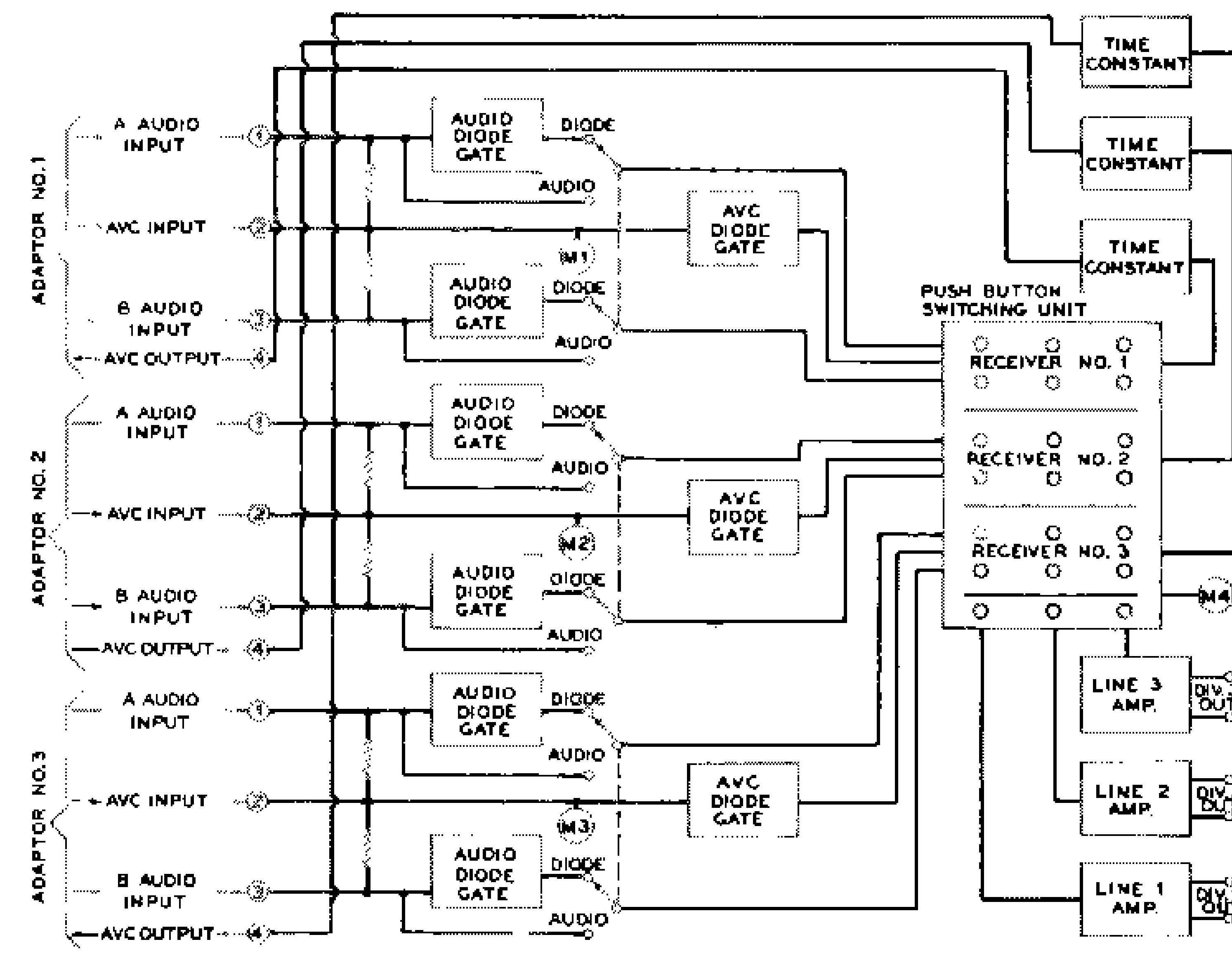


FIG. 3. SINGLE-SIDEBAND RECEIVER ADAPTOR. NOTE CRYSTAL FILTERS

*President, Crosby Laboratories, Inc., Hicksville, Long Island, N. Y.





FIGS. 1 AND 7. FUNCTIONAL DIAGRAMS OF THE ADAPTOR AND COMBINER UNITS

control, to produce a new intermediate frequency of 100 kc.

The 100-kc. IF signal, with modulation components, is amplified and applied to upper and lower sideband filters having pass-bands from 100 kc. to 106 kc. and from 94 kc. to 100 kc., respectively. These filters can be seen in Fig. 3, which is a rear view of the adaptor. Responses of the filters are shown in Fig 4. The 100-kc. signal is applied also to a sharply-tuned crystal filter with a passband of 20 cycles, which removes the sidebands as shown in Fig. 5. This is fed to a two-stage carrier amplifier, in which the carrier amplitude is adjusted to an optimum level, as required in compensating for carrier reduction at the single-sideband transmitter. From this point, the amplified carrier is applied to a three-stage limiter, a pair of diodes which supply AVC and carrier meter voltages, and a keying amplifier which forms a part of a carrier-off alarm circuit.

From the three-stage limiter the carrier, reconditioned and exalted by the filter, carrier amplifier, and limiter, is applied to one side of a Reconditioned Carrier-Local Carrier selector switch identified as the LC-RC switch in Fig. 1. A

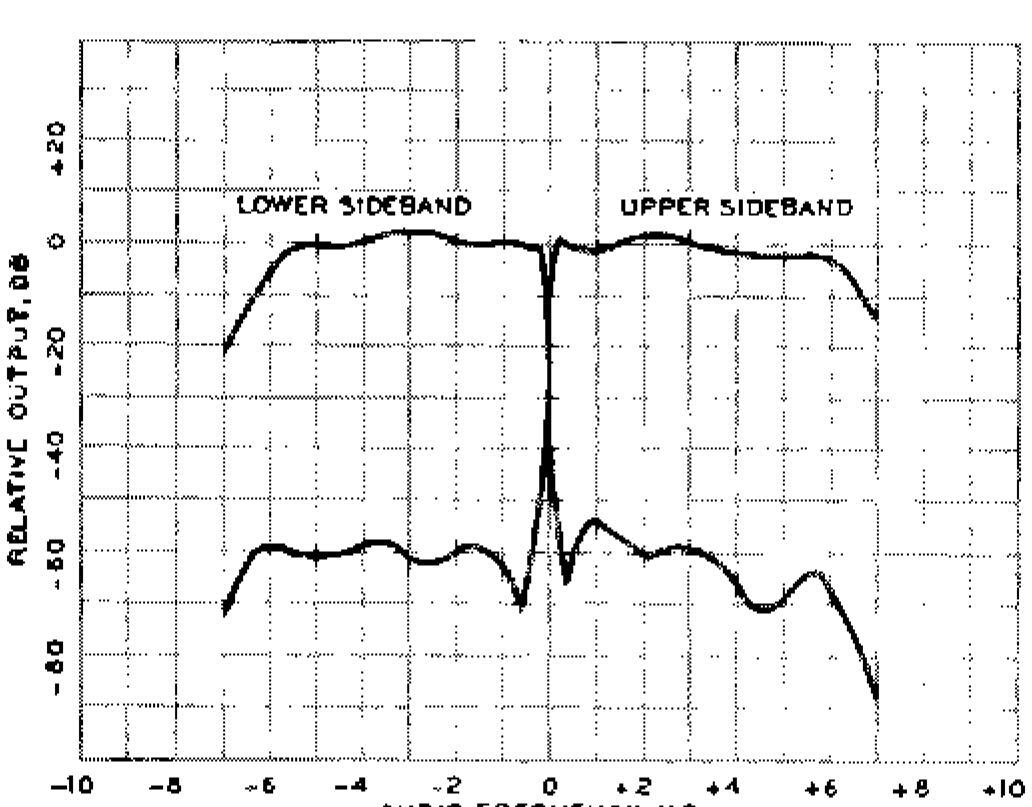


FIG. 4. COMPLEMENTARY RESPONSES OF SIDEBAND FILTERS IN AN ADAPTOR

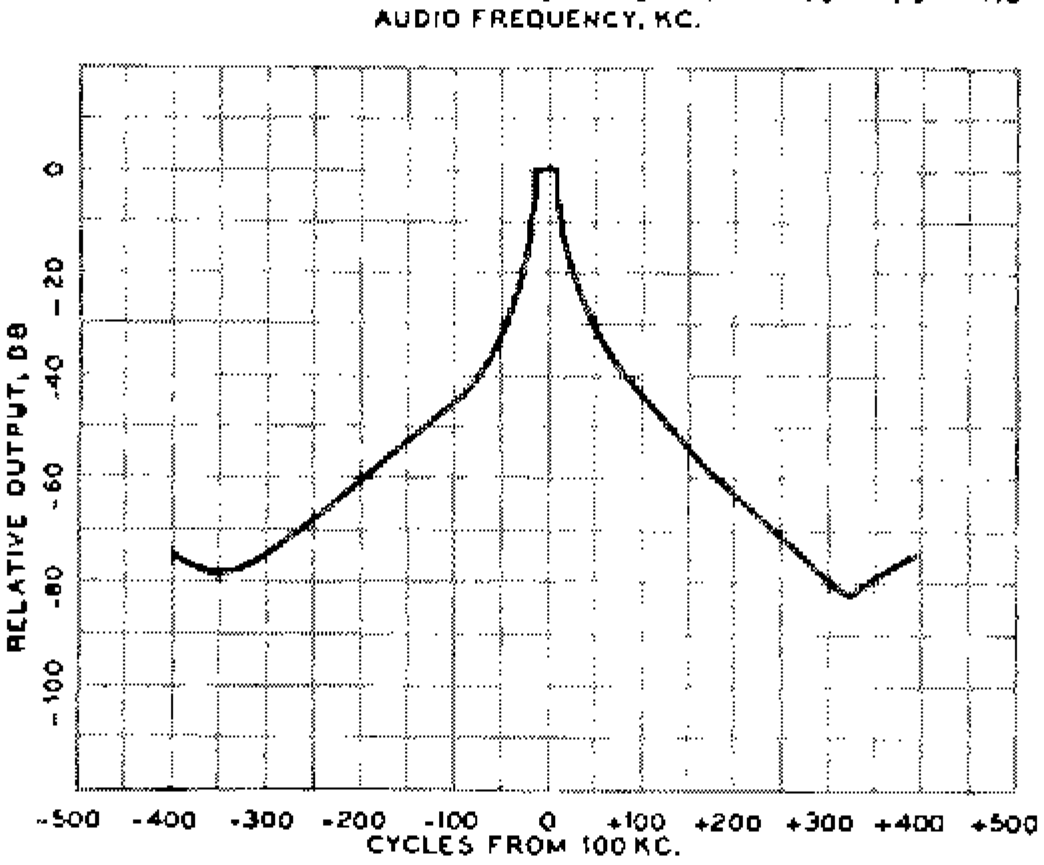


FIG. 5. PERFORMANCE OF THE CARRIER SEPARATION CRYSTAL FILTER

locally-generated 100-kc. carrier from a crystal oscillator is applied to the opposite side of the LC-RC switch. Thus, a choice of reconditioned exalted carrier or local carrier for single sideband reception is available. From the LC-RC switch, the selected carrier is fed to an AM-PM phasing network. This is used in establishing the proper phase relationship between the sidebands and the selected carrier in amplitude-modulated double-sideband signal reception and in phase-modulated double-sideband signal reception.

The reconditioned or local carrier and the sideband signals from the two sideband filters are applied through a reception selector switch to individual detectors for channels A and B. Here, exalted-carrier detection is provided by a triple-triode product-type detector; this unique circuit eliminates harmonic and cross-modulation distortion caused by selective fading of the carrier component. The audio signals in each channel are then applied, through low-pass filters, to separate audio amplifiers associated with the two channels.

The reception selector switch provides for operation with virtually any method of reception. When the sideband filters are switched into the circuit, single-sideband exalted-carrier reception is provided. Either the upper or lower sideband of a conventional double-sideband AM transmission can be selected individually, and the signals applied to separate detectors and audio amplifiers, or both sidebands of a twin-channel multiplex transmission can be received concurrently, with the individual signals being applied to the respective detectors and audio amplifiers. When the signals are selected directly from the 100-kc. IF amplifier and the AM section of the phasing network, exalted-carrier double-sideband AM reception is obtained. When the PM section of the phasing network is used, exalted-carrier reception of phase modulated double-sideband signals is provided. When a connection is made directly to the diode output of the communication receiver, conventional double-sideband AM reception as provided by the basic receiver is possible.

100-kc. carrier voltage from the first stage of the three-stage limiter is applied to an amplifier driving a crystal discriminator, which produces an output voltage proportional to small frequency deviations from the mean frequency of 100 kc. This voltage is rectified by the AFC diodes. The DC error voltage obtained is impressed on the grid circuit of a reactance-tube driver, which contains a storage capacitor for Infinite Time Constant (ITC) operation. In the event that the IF carrier falls below a predetermined level in the ITC circuit, the AFC diodes are disabled. When the carrier reappears, normal AFC action is restored. This protects the reactance tube and oscillator from spurious control by un-

Continued on page 39

DIVERSITY UNITS

(Continued from page 30)

desired signals or noise during intervals when the desired radio carrier drops below a designated threshold strength. At the same time, while the AFC voltage is removed, the residual charge on the storage capacitor of the reactance-tube driver remains at a substantially constant potential over periods of several minutes, thus holding or freezing the high-frequency ocsillator at a frequency in close proximity to its last-corrected frequency. In normal operation, when carrier is present, the AFC circuit is relatively immune to high noise peaks or interference from jamming signals because of the protection afforded by the crystal filter, limiter, and crystal discriminator.

The 100-kc. signal voltage, after passing through the crystal carrier filter and the carrier amplifier, is rectified by an AVC diode. Normally, it is then applied to the AVC circuit of the communication receiver to provide protection against interference which might otherwise gain control of the AVC system. When used in a diversity system, the AVC voltage is applied to the diversity combiner, described below, and is afterward fed back to the communication receiver. A switch permits the AVC system to be controlled either from the filtered and rectified carrier alone, as above indicated, or from the total rectified signal and sidebands, which is advantageous for tuning purposes. The carrier meter furnishes visual indications of signal level and proper tuning.

Diversity Combiner: The operating principle of the diversity combiner, shown in Fig. 6, is that of a diode gate controlled by the rectified signal so that the gate selects automatically the audio output from the receiver having the strongest rectified carrier or total signal.

The audio signal from each channel of each receiver, Fig. 7, is fed through its individual diode gate to a common load resistor, incorporated in a push-button switching unit. DC voltage from the AVC circuit of each receiver is fed to the respective audio diode gates of each channel through isolating resistors, as shown in the diagram, and directly to an AVC diode gate. The diode gates act as controlled resistances, each of which has a low value when the bias from the rectified signal is high, and a high value when the bias is low. The audio voltage fed through the controlled resistance to the common load resistance, therefore, is selected primarily from the receiver with the strongest rectified carrier or total carrier at any given moment.

Continued on page 40

DIVERSITY UNITS

(Continued from page 39)

The selected audio voltage in each audio channel is applied to one of the audio amplifiers in the combiner, and the DC voltage from the strongest signal is fed back to the individual receivers through selected time-constant networks to apply common AVC. Direct addition of the audio outputs of each receiver can be obtained in lieu of diode-gate selection when the DIODE-AUDIO switch is in the AUDIO position.

The AVC voltages in the receiver channels are applied to vacuum-tube voltmeters, shown in Fig. 7 as M1, M2, and M3, to provide indications of signal strengths. VTVM M4 is furnished to indicate logarithmically the combined signal strength. Audio signal level in any channel can be measured by means of VU meter incorporated in the combiner but not shown in the diagram.

Conclusion: By means of the push-button switching unit, which contains

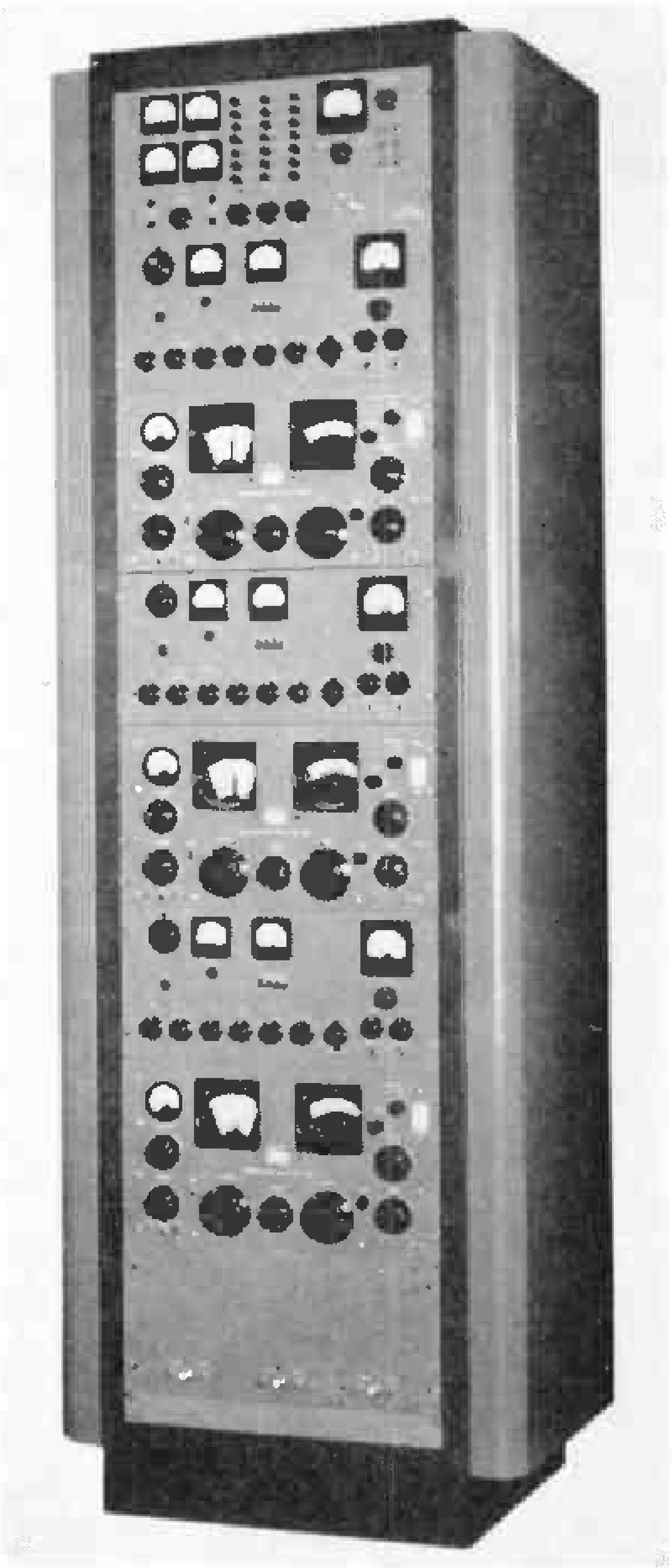


FIG. 8. COMPLETE TRIPLE-DIVERSITY SYSTEM

the common-load resistors and dummy-load resistors, any receiver channel can be connected individually to its dummy load to feed any of the three audio line amplifiers; alternatively, signals from any combination of two or three receivers connected in a diversity arrangement on

Concluded on page 43

DIVERSITY UNITS

(Continued from page 40)

a common load can be fed to any one of the audio amplifiers. This provides full flexibility of interconnection between the various receiver channels and the three audio amplifiers, so that they can be set up in any conceivable arrangement of triple-diversity, dual-diversity, or single-receiver systems with a choice of either sideband from any receiver or combination of receivers. Such flexibility ensures dependable operation under virtually any combination of operating requirements

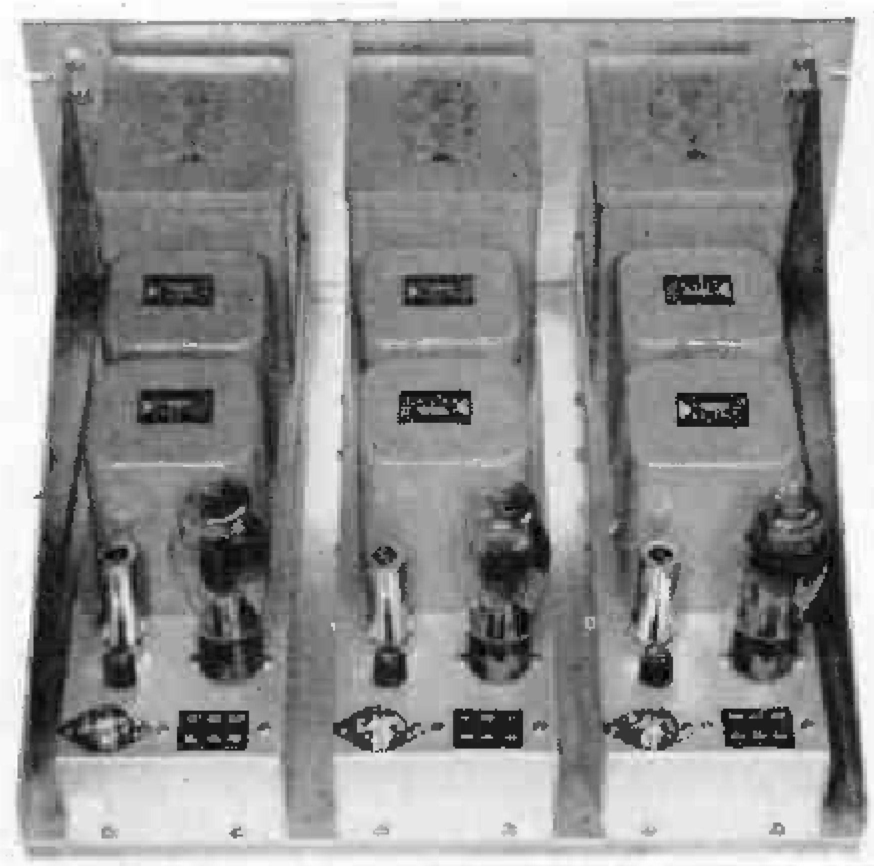


FIG. 9. POWER SUPPLIES FOR THREE ADAPTORS

and atmospheric conditions. Fig. 8 shows a complete triple-diversity equipment rack: the diversity combiner occupies the top space; under it are three groups of adaptors and receivers; finally, at the bottom, a power supply panel furnishes power for the adaptors. A rear view of this panel is given in Fig. 9.