$$\text{Gain} = 10 \log_{10} 10^4$$

$$\text{Now } \log_{10}10^4 = 4$$

$$\therefore \text{Gain} = +\ 40 \text{ db.}$$

Thus, + 40 db. indicates a power gain of $\frac{10}{10^{-3}} = 10{,}000$.

11. Given the gain of an amplifier in decibels the ratio of output to input powers can be obtained.

$$\text{Power gain in db} = 10 \log_{10} \frac{P_2}{P_1}$$

$$\therefore \log_{10} \frac{P_2}{P_1} = \frac{\text{Power gain in db.}}{10}$$

$$\therefore \frac{P_2}{P_1} = \text{Antilog}_{10} \frac{\text{Power gain in db}}{10}$$

Thus, in an amplifier which has a power gain of +20 db, the power output for an input of 100mW is:—

$$\frac{P_2}{P_1} = \text{Antilog}_{10} \frac{20}{10}$$

$$\frac{P_2}{P_1} = \text{Antilog}_{10} 2$$

$$\frac{P_2}{P_1} = 100$$

$$P_2 = 100 \times P_1$$

$$P_2 = 100 \times 10^{-1}$$

$$\therefore P_2 = 10 \text{ W.}$$

12. There are obvious advantages in using the decibel in power transfer. Multiplication and division are replaced by addition and subtraction, and + and − signs distinguish gains and losses. However, the the original reason for using logarithmic units was that the human ear responds to power *ratios* in such a way as to interpret them as *differences* in signal strength; *squaring* a power *doubles* the sound intensity, and so on. Thus, the decibel is a natural unit for expressing sound intensities since it is logarithmic, and it is now universally employed for measuring gain and loss in all cases of power transfer.

Absolute Powers Expressed in Dbm

13. Instead of recording the gain or loss of an amplifier or attenuator, it may be required to measure the *actual power level* at some stage in the circuit. This means comparing the observed power level P_2 with some *standard* power level P_1. The standard usually adopted is 1 mW. Power levels expressed in decibels with reference to a standard power of 1 mW are written as so many "*dbm*". Using this standard, any power P can be expressed as $10 \log_{10} P$(dbm). Thus:—

$$1\text{ W} = 10 \log_{10} 1{,}000 = +30 \text{ dbm.}$$

$$5\text{mW} = 10 \log_{10} 5 = +7 \text{ dbm.}$$

$$5\mu\text{W} = 10 \log_{10} \frac{5}{1{,}000} = -23 \text{ dbm.}$$

Current and Voltage Ratios

14. Consider two equal resistances each of R ohms carrying currents of r.m.s. values I_1 and I_2, and having voltages across them of r.m.s. values V_2 and V_2 respectively. The powers developed in these two resistors are:—

$$P_1 = I_1^2 R = \frac{V_1^2}{R}$$

$$P_2 = I_2^2 R = \frac{V_2^2}{R}$$

$$\therefore \frac{P_2}{P_1} = \left(\frac{I_2}{I_1}\right)^2 = \left(\frac{V_2}{V_1}\right)^2$$

The power ratio $\frac{P_2}{P_1}$ expressed in decibels is:—

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \left(\frac{I_2}{I_1}\right)^2$$

$$\therefore 10 \log_{10} \frac{P_2}{P_1} = 20 \log_{10} \left(\frac{I_2}{I_1}\right)$$

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \left(\frac{V_2}{V_1}\right)^2$$

$$\therefore 10 \log_{10} \frac{P_2}{P_1} = 20 \log_{10} \left(\frac{V_2}{V_1}\right)$$

Thus, *provided that the two resistances are equal* through which the two currents I_1 and I_2 (or across which the two voltages V_1 and V_2) are measured the gain or loss of a circuit in decibels is:—

$$\text{Gain or loss} = 10 \log_{10} \frac{P_2}{P_1}$$

$$\text{Gain or loss} = 20 \log_{10} \frac{I_2}{I_1}$$

$$\text{Gain or loss} = 20 \log_{10} \frac{V_2}{V_1}$$

15. In Sect. 5, Chap. 2 it was stated that the bandwidth of a series tuned circuit was the separation between two frequencies either side of resonance at which the current has

"This leaf issued with A.L. 4"

fallen to 70% of its peak value. In terms of decibels, the current ratio is:—

$$20 \log_{10} \frac{0 \cdot 707}{1} = -3 \text{ db.}$$

The bandwidth is then expressed as so many kc/s at "3 *db down*". Another figure at which the bandwidth is commonly measured is 6 *db down*. At this latter figure the current has fallen to *half* its peak value.

Decibel Meters

16. By comparing the voltages they cause when connected in turn across a standard impedance, the powers of two sources can be compared. A high impedance voltmeter (Fig. 4) is connected across the impedance

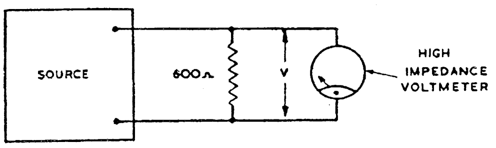

Fig. 4. POWER COMPARISON

and the meter can be calibrated to read power levels above and below 1 mW directly in dbm. The standard impedance usually chosen is a pure resistance of 600 ohms. The r.m.s. voltage V which must be applied across a resistance of 600 ohms in order to dissipate the reference power of 1 mW is 0·775 volts. Thus, when the voltmeter registers 0·775 volts, the reference power of 1 mW is developed and the pointer indicates O dbm on the scale. When the voltmeter registers r.m.s. voltage V_1, the power level is $20 \log_{10} \frac{V_1}{0 \cdot 775}$ (dbm). For instance the power dissipated in the 600 ohms resistance when the voltmeter reads 2 volts r.m.s. is:—

$$20 \log_{10} \frac{2}{0.775} = 20 \times 0 \cdot 417$$
$$= + 8 \cdot 23 \text{ dbm.}$$

The scale is calibrated directly in dbm in accordance with Fig. 5. The instrument

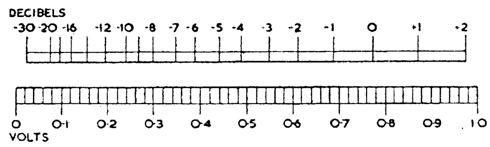

Fig. 5. CALIBRATION OF VOLTMETER TO READ DBM.

used up to frequencies of the order of 50 kc/s will be a rectifier type, moving-coil meter; at higher frequencies, special *valve-voltmeter* circuits are used (see Sect. 18).

The Neper

17. This is a unit based on the *natural* logarithm of the ratio of two *current* values, regardless of the resistance value of the circuits. It can be used to express power and voltage ratios when the resistances of the components are equal. It is mainly used in calculations concerned with filters and attenuators in line transmission. The gain or loss of a circuit in nepers is:—

$$\text{Gain or loss} = \log_e \frac{I_2}{I_1}$$

$$\text{Gain or loss} = \log_e \frac{V_2}{V_1}$$

$$\text{Gain or loss} = \tfrac{1}{2} \log_e \frac{P_2}{P_1}$$

Note. There are 8·686 decibels to the neper.

4.12 OPERATION — SELECTIVE CALL

The selective calling system is an optional feature. Check that it is fitted to the transceiver before using this function.

Each transceiver is assigned a selective call code (000 to 254). This code is internally programmed in the selective calling module.

Press the "S.C." key and enter the three digit code for the desired station. Press the "CALL" button, this will switch the transmitter on and will then send the selective call code.

The station called will stop scanning and send back a transpond signal. This resond signal should be monitored to ensure that the call was received.

Once the call is received, the selective call initiates a 150 second scan hold timer, displays "CALL" on the LCD display, and sounds the call buzzer.

When a call is received, turn on the loudspeaker and answer the call. Pressing the transmit switch automatically updates the scan hold timer for 150 seconds. Alternately press the "SCAN" key to stop the scan. After the call is completed, press any key on the keypad to cancel the "CALL" display. If the scan mode is in use, press the "SCAN" key again to initiate scan.

The loudspeaker may be turned off to eliminate background noise while monitoring the channel in scan mode.

4.13 OPERATION - TRANSCALL

The Transcall feature is optional. Check that it is installed before attempting to use it.

Each transceiver in the Transcall domain utilizes the three-digit Selcall code (000 to 254) for identification. This is internally programmed in the option module. In addition, each unit in the system should be programmed to scan the same number of "Transcall" channels. This is also an adjustment in the option module (see Section 12.7 of the technical manual).

To initiate a Transcall, press the "S.C." key and enter the three-digit code for the desired station. Flip the toggle switch from "SC" to "TC", and press the "CALL" button after the scan has begun. An arming tone will sound, and the transceiver will now be under full control of the Transcall circuit. Normal operation involves scanning, along with brief transmissions on each channel. When both stations become synchronized, they will step together and seek the channel providing best communications. Following this sequence (lasting a maximum of five minutes), the transceiver will automatically switch to the best channel and sound an alarm. An "error" message will appear if the stations do not achieve sync.

4.13.1 ABORT/EXIT FROM TRANSCALL MODE

The Transcall calling sequence may be stopped in progress, provided that the two stations have not yet synchronized. To abort, the calling station must hold the "CALL" key in for two seconds.

Exiting the transcall mode (either before "CALL" is pressed, or after the best channel has been selected), is achieved by flipping the toggle switch from "TC" to "SC", then pressing "F" on the keypad. The display will clear within three seconds.

4.13.2 TRANSCALL SCAN

When scanning in the transcall mode, the receiving station will also respond to a valid selcall. The scan limit is determined by the setting internally programmed in the option module.

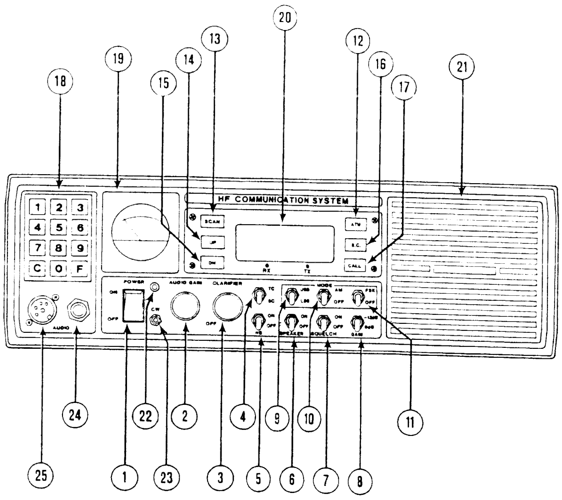

FIGURE 4-1. Front Panel Controls.