

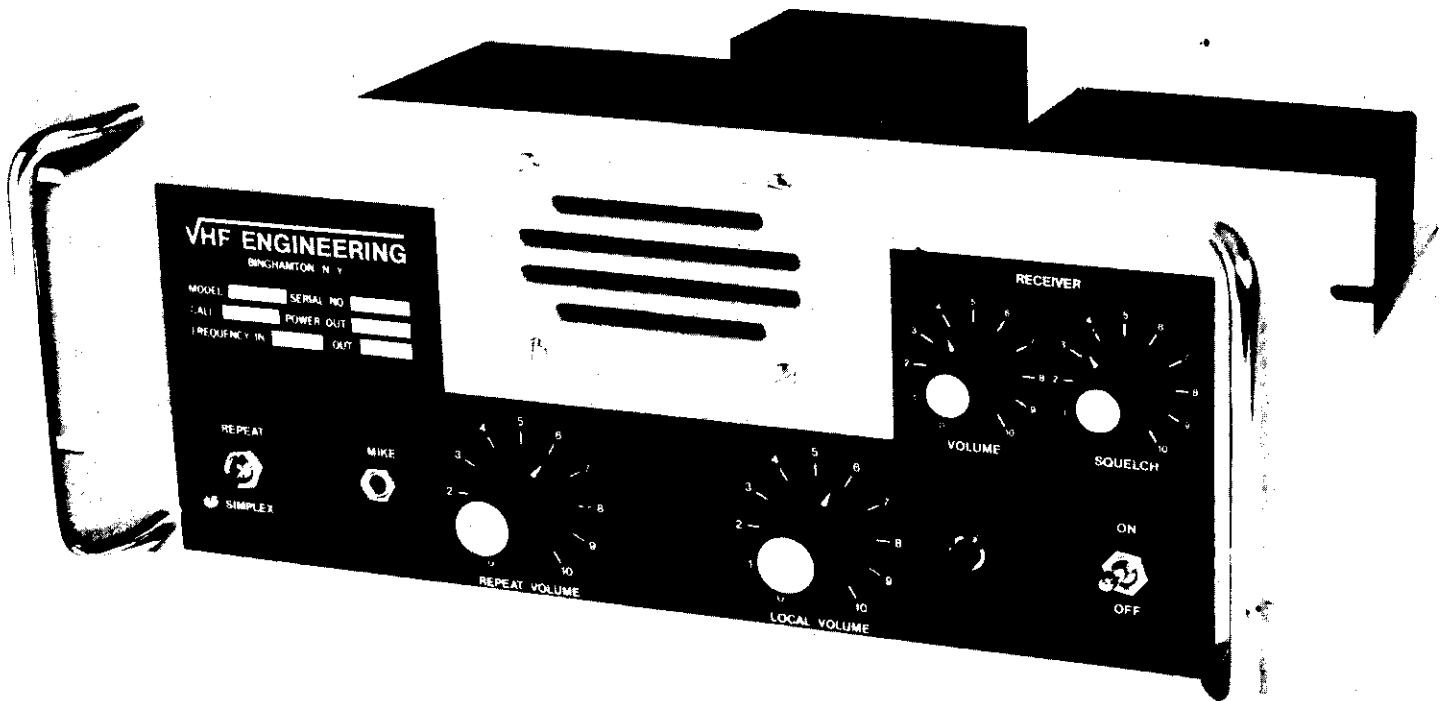
REPEATER MANUAL

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REV.01

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MODEL RPT-50 • MODEL RPT-144 • MODEL RPT-220 • MODEL RPT-432

UAGC Rev 6.5
R.V. 9



PRICE: \$5.00

Vhf engineering

DIVISION OF BROWN ELECTRONICS CORP.

320 WATER ST. / BINGHAMTON, N.Y. 13901 / Phone 607-723-9574

SPECIFICATIONS

	<u>RPT-50</u>	<u>RPT-144</u>	<u>RPT-220</u>	<u>RPT-450</u>
<u>Transmitter</u>				
Frequency Range	49-54MHz	142-175MHz	210-240MHz	420-470MHz
RF Power Output (nominal)	25W	15W	15W	10W
Frequency Stability (-10 degrees C to +60 degrees C)	.001%	.001%	.001%	.001%
Modulation-FM (adjustable to)	5kHz	10kHz	15kHz	30kHz
Output Impedance	50ohms	50ohms	50ohms	50ohms
<u>Receiver</u>				
Frequency Range	49-54MHz	142-175MHz	210-240MHz	420-470MHz
Sensitivity (20dB quieting)	.3uV	.3uV	.3uV	.3uV
Selectivity \pm 30kHz	70dB	70dB	70dB	70dB
(optional \pm 25kHz)	(90dB)	(90dB)	(90dB)	(90dB)
Frequency Stability (-10 degrees C to +60 degrees C)	.001%	.001%	.001%	.001%
Modulation Acceptance	\pm 7.5kHz	\pm 7.5kHz	\pm 7.5kHz	\pm 7.5kHz
<u>Power Requirements</u>				
117VAC Maximum Current or 13.8VDC Maximum Current	1A 5A	1A 3.5A	1A 3.5A	1A 3.5A

LIMITED WARRANTY

Factory wired units are fully warranted for 90 days from purchase date. The unit must be returned to the factory postpaid with a note describing difficulty and date of purchase; include a check to cover return postage. Our liability under warranty is limited to repair, adjustment or replacement of units proven to be defective. Power devices are warranted to be within 1dB of specifications. No further warranty is expressed or implied. Units modified or obviously misused will not be covered by the warranty.

The enclosed warranty card must be filled out and returned within 10 days of purchase in order to validate the warranty.

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I. DESCRIPTION

VHF Engineering has designed its series of repeaters, the RPT-50, RPT-144, RPT-220 and RPT-432 for use on the amateur frequencies and those MARS frequencies adjacent to the amateur bands. These solid state repeaters are constructed from high quality components and will offer excellent performance with a minimum of service.

The repeaters consist of a receiver, transmitter, and amplifier, all in shielded enclosures; a power supply, and a Morse code identifier. Interfaces are provided to permit connection to an auto-patch or an optional touchtone control decoder. The units come complete with a local microphone and monitor speaker and are designed for either 19" rack mounting or for table top operation.

VHF Engineering offers a touchtone decoder control unit (TD-3) and a private line (PL) control unit (TS-1) for repeater use. The TD-3 takes standard touchtones or other selected tones from the repeater input or from an auxiliary source and provides control of repeater functions. The TS-1 takes standard private line (PL), subaudible tones from the repeater input and provides repeater access. Both units are supplied with information for interfacing to the VHF Engineering repeaters.

II. INSTALLATION

Antennas

In a good repeater installation it is important to erect a good antenna system as discussed in the appendix entitled "Antenna Requirements". It is also important to use a good quality 50ohm (nominal) antenna cable such as RG-8U for the antenna feedlines. For frequencies above 150MHz, or for runs longer than 100 ft, a low-loss hard line is "preferred". The receive and transmit feedlines between the repeater and the duplexer or their respective antennas must be separated by at least 6-12 inches. Due to the fact that coax has some leakage, the cables should not be taped into one bundle or passed through the same hole in the wall of the repeater installation. In duplexer installations double shielded coax cables between the repeater and duplexers is preferred. Any signal leakage between the receiver and transmitter cables or excessive losses in the antenna cables will degrade repeater performance.

Receiver Preamps

Receiver preamps are not recommended. Most preamps will amplify the unwanted signals as well as the wanted and will just create intermod and front end overload.

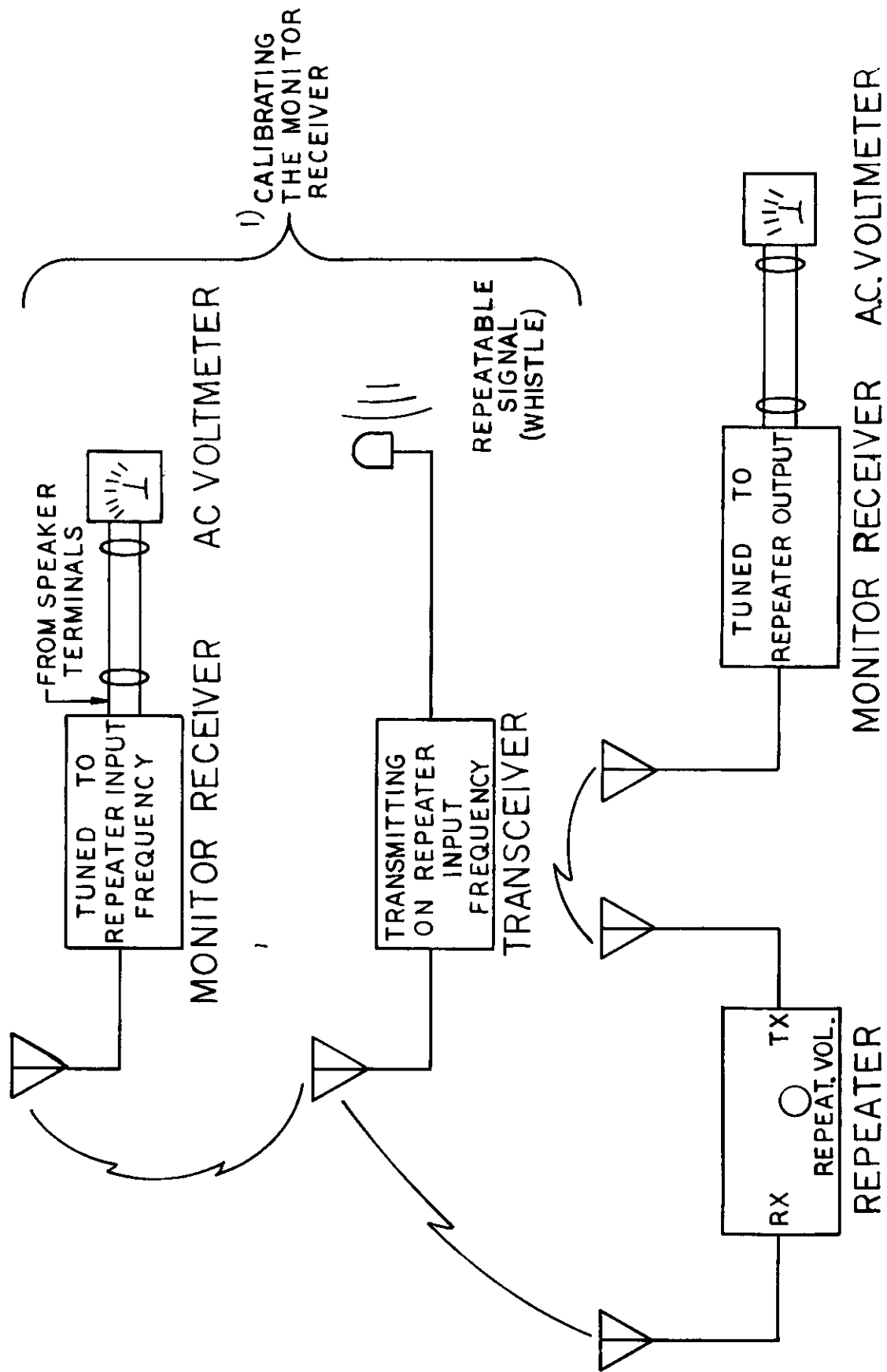
Power Amplifiers

If additional transmit power is needed, a power amplifier may be added. Keep in mind that for every dB the transmit power is increased, an additional dB must be added to the minimum 60dB antenna separation requirement. The amplifier selected must be able to handle the high duty cycle encountered in repeater operation.

INITIAL ADJUSTMENTS

The repeater must not be operated unless a properly matched antenna or dummy load is connected to the "RF OUT". Failure to follow this instruction may result in permanent damage to the final amplifier.

- 1.) Connect the receive antenna to "RF IN". Connect the transmit antenna to "RF OUT". An isolation figure of at least 60dB is necessary. See Appendix A for the required antenna separation. Cavities or duplexers with 60dB or better isolation will also be suitable.
- 2.) Preset controls as follows:
ON-OFF to off
REPEAT - SIMPLEX to simplex
LOCAL VOLUME to full on (C.W.)
REPEAT VOLUME TO FULL OFF (CCW)
SQUELCH to full off (CCW)
VOLUME to one-half
- 3.) Plug the line cord into a 120 V.A.C. outlet.
- 4.) Turn the power (ON-OFF) switch to "ON". The pilot light will light and background noise should be heard at this point.
- 5.) Set the RECEIVE - VOLUME slightly above a comfortable level of background noise.
- 6.) Set the SQUELCH control to quiet the receiver.
- 7.) Set the REPEAT - SIMPLEX switch to repeat.
- 8.) Set the REPEAT VOLUME. This can be accomplished in the following manners depending upon the available equipment.
NOTE: Receive VOLUME changes will affect REPEAT VOLUME settings.
 - a.) If a modulated signal generator and deviation meter are available, inject a 1kHz modulated signal having 3kHz deviation into the repeater input and, while monitoring the deviation of the output signal, adjust REPEAT VOLUME until an output signal with 3kHz deviation is obtained.
 - b.) If such equipment is not available, an acceptable adjustment can be made with a monitor receiver capable of receiving the repeater input and output frequencies.
 1. Tune the monitor receiver to the input frequency of the repeater. Connect a sensitive AC voltmeter across the speaker terminals and adjust the volume setting to give a reading of at least a quarter of scale for the "calibrating" signal. This "calibration" signal can be any repeatable signal from a friend's transmitter; e.g., whistling a fixed distance away from a microphone. Note this reading; it is used in the next step. (The monitor receiver is "calibrated", do not touch its volume setting.)



2) SETTING REPEAT VOLUME

2. Tune the monitor receiver to the output frequency of the repeater and have the "calibrating" signal repeated at the input frequency of the repeater. Adjust the REPEAT VOLUME until the meter reading obtained in step 1 is indicated. This completes the deviation adjustment.

When the monitor receiver is switched from the input to output, little change in volume for a given signal should be noticed if this step is successful.

NOTE: DO NOT TOUCH THE DEVIATION CONTROL ON THE TX BOARD. IT IS SET AT THE FACTORY TO GIVE PROPER DEVIATION FOR THE LOCAL MICROPHONE. IF THE TX BOARD IS SERVICED OR CHANGED, REFER TO THE TX MANUAL FOR DEVIATION ADJUSTMENT PROCEDURE.

- 9.) COR ADJUSTMENTS: Refer to the COR manual for proper adjustments.
- 10.) CWID ADJUSTMENTS: Refer to the CWID manual for proper adjustments.

III. OPERATING INSTRUCTIONS

The repeater should be in proper operating condition after following the details of the installation instructions. The REPEAT VOLUME and receive VOLUME were set then. The repeater need only be checked by a monitor receiver and frequency counter periodically to insure its proper operation. The remainder of the controls can be set as needed.

- 1.) The LOCAL VOLUME to comfortable level.
- 2.) The SQUELCH to a level for reliable operation and desired range of acquisition by controlling the minimum strength signal to bring the repeater up.
- 3.) MIKE INPUT: For at site communication: especially useful for coordinating adjustments of the repeater system.
- 4.) REPEAT - SIMPLEX switch:

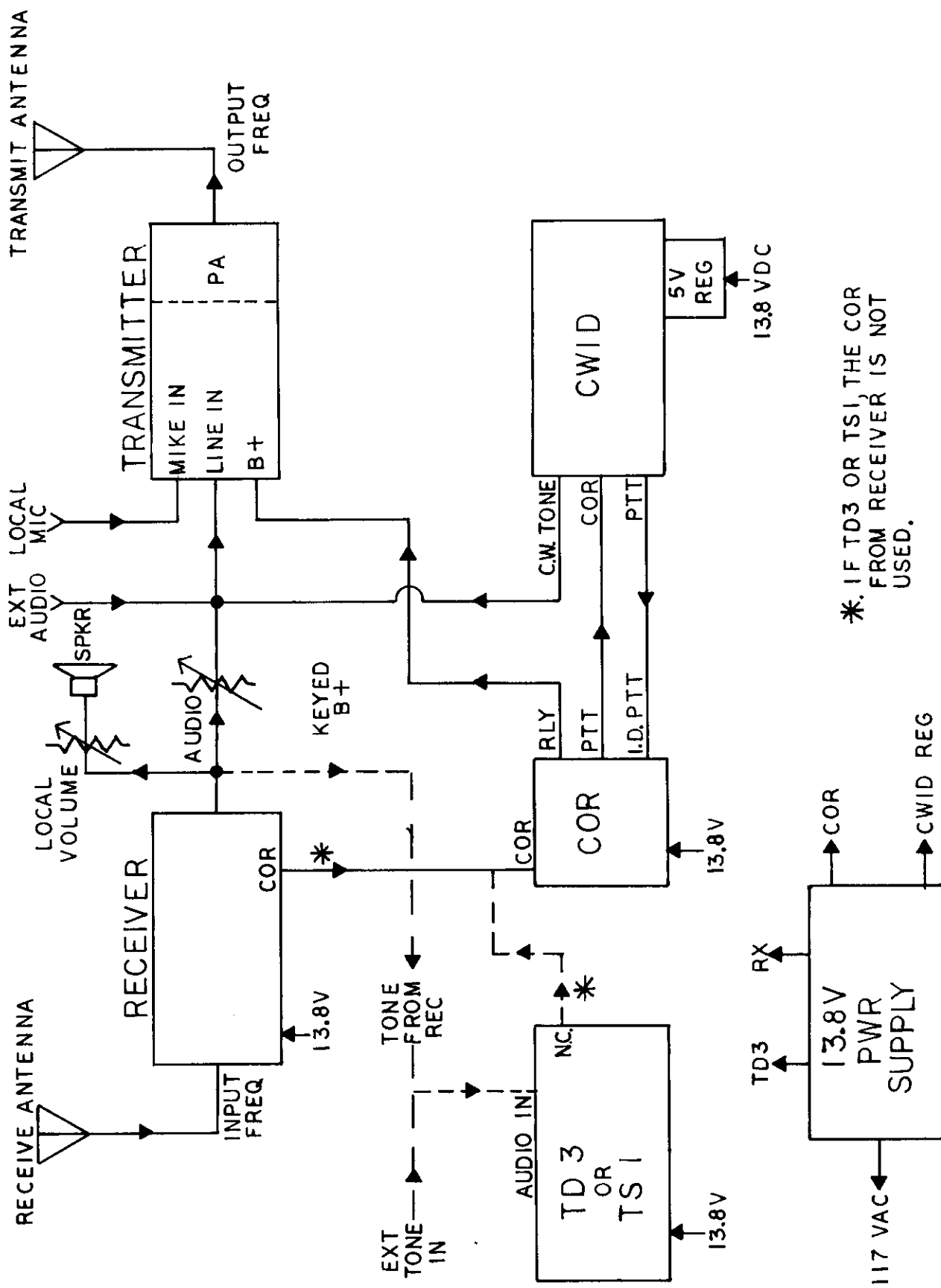
The SIMPLEX position disables the COR circuitry. The received signal is not repeated, but the audio is delivered to the repeater's speaker.

In the REPEAT position, the repeater retransmits the signal as detailed in the "Theory of Operation".

In both positions, the local microphone can be used for transmission.

IV. THEORY OF OPERATION

The receive audio signal is combined with the audio from the CW identifier and any input from the AUDIO IN jacks, and is fed to the transmitter line input for re-transmission. The receiver also provides a control signal to the COR terminal of the carrier oper-



VHF ENGINEERING REPEATER SYSTEM

ated relay and timing circuit (the COR). When a signal is present, the COR keys the transmitter and power amplifier and starts the time out timer. The time out timer will time for a fixed period (approximately 3 minutes) and will turn off the transmitter-amplifier at the end of this period unless the received signal disappears before the time out occurs. The squelch tail timer will hold the transmitter power on for about 3 seconds (adjustable) after the received signal disappears. After this time the transmitter is turned off and both COR timers are reset. If the repeater times out, the received signal must be dropped before the COR timers are reset and the transmitter can be powered again.

The CWID's operation is dependent upon the PTT output from the COR. When a signal is present at the receiver input after a long idle period, the CWID will provide a keyed audio tone of the repeater's programmed call sign. The CWID keeps the repeater from timing out during this identification by providing a signal to the COR's ID PTT terminal. The timer in the CWID circuit will reset and begin to time at the end of the tone identification. This timer will time for an adjustable period, typically 3 minutes. After this period the CWID will identify again, provided a signal is still being received.

V. TUNE-UP PROCEDURES

Wired and tested units are tuned to specifications at the factory using standard 50ohm termination. If properly installed, no tuning should be necessary. However, if tuning is necessary, consult the supplementary manuals describing the unit to be tuned.

VI. SERVICING

For servicing information consult the supplementary manuals at the end of this manual.

II. CUSTOMER SERVICE

VHF Engineering's Customer Service department will assist customers with technical problems concerning all VHF Engineering units. Should assistance be required, please contact the Customer Service Department at (607) 723-9574. Units having serious problems may be returned postpaid to the factory without authorization for evaluation and repair estimates with a note detailing the difficulty. Units qualifying for warranty service will be covered according to the warranties detailed in their manuals. For units not covered by a warranty, a nominal service fee plus parts and return postage will be charged.

Address units to be returned to: Customer Service Department
VHF Engineering
320 Water Street
Binghamton, New York 13902

VIII. APPENDICES

APPENDIX A - ANTENNA REQUIREMENTS

In order for the repeater to operate correctly, isolation must be provided between the transmit and receive antennas. The minimum required isolation for VHF Engineering repeaters is in the order of 60dB. The most practical way to achieve this isolation is to use a duplexer in conjunction with a single antenna. Duplexers typically provide isolation in the range of 80dB.

Repeaters may also be operated using separate antennas for the transmitter and receiver. If this is the case, sufficient vertical or horizontal separation is required to provide the needed isolation.

The following separations may be used for $\frac{1}{2}$ wave dipole antennas:

Approximate 60dB Isolation Distances

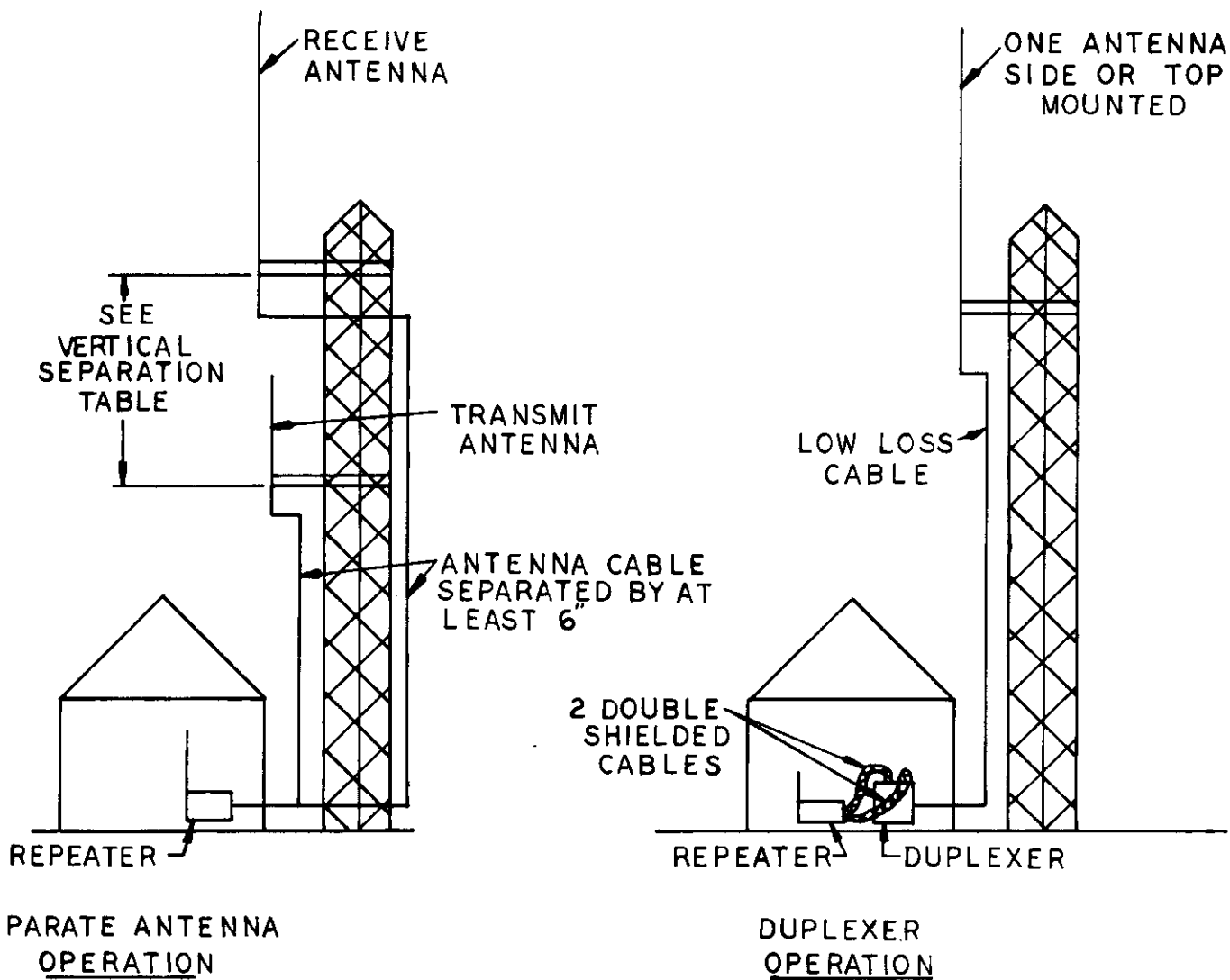
<u>Band</u>	<u>50MHz</u>	<u>146MHz</u>	<u>220MHz</u>	<u>440MHz</u>
Vertical Separation	200'	50'	30'	20'
Horizontal Separation	2,500'	800'	500'	250'

Obviously, vertical separation is more practical and is generally used. Vertical separation takes advantage of the radiation null off the ends of a vertical antenna. Any horizontal offset will degrade this isolation figure. Therefore, for best results, it is important to mount the antennas directly over one another. For maximum range, the top antenna should be connected to the receiver.

The 60dB separation distances shown in the table above are the minimum spacing for $\frac{1}{2}$ wave dipoles. The minimum multi-element higher gain antenna spacing will vary depending on radiation patterns and reflection from ground or other objects.

The antenna isolation figure can be accurately measured by using the following procedure:

Connect a calibrated signal generator (Measurements Model 800A or equivalent) to the repeater's receiver antenna jack through a short piece of coax. Center the generator's output frequency in the receiver's bandpass and note the lowest output level required to open the squelch (Typically about - 127dBm (.29uV)). Then connect the transmitter antenna to the signal generator and connect the receiver antenna to the repeater's receiver. Increase the output of the generator until the squelch breaks. Recheck the generator's output frequency to insure that it is in the center of the receiver bandpass. Again, note the lowest output level needed to open the squelch. Subtract the reading in dBm from the earlier



TYPICAL REPEATER INSTALLATIONS

reading. This is the antenna isolation figure in dB. If the output level on the generator is calibrated only in uV, multiply the logarithm of the ratio of the two voltages by 20 to get the isolation in dB.

Under 175MHz the isolation figure may be improved by installing a piezoelectrical filter in the receive line. A piezoelectric filter (Piezo Technology Inc. Model 2133 VBP or equivalent) will add an additional 30dB to the antenna isolation figure. The piezoelectric filter will also improve intermod and receiver desense from strong adjacent signals.

High quality coaxial cable is an absolute requirement for proper operation of the repeater. For short runs or frequencies below 150MHz, a good quality RG-8/U is suitable. Low-loss hard-line is preferred for long runs and higher frequencies. All antenna connections must be thoroughly waterproofed. If separate antennas are used for receive and transmit, the cables should be separated throughout their run by at least 6-12 inches.

APPENDIX B - DUPLEXERS

The duplexer is used in repeater service to allow the use of a single antenna for reception and transmission. Using a single antenna for receiving and transmitting will help to equalize the repeater's receive and transmit range. The duplexer will provide over 80dB isolation of the receiver input from the transmit carrier and any sideband noise, while providing a low loss path for the transmit and receive signals. A bandpass - band-reject duplexer will help to eliminate desensing and intermod problems.

VHF Engineering can supply duplexers for all repeaters when they are required. Literature on the duplexers is available on request.

APPENDIX C - COMMON REPEATER PROBLEMS

DESENSE

One of the most frequent problems encountered in the operation of a repeater installation is desensing. This is caused by the transmit signal blocking the receiver. In severe cases this may cause a cyclic "chopping" of the repeater. Less severe desense is evidenced by an apparent drop in received signal strength when the transmit section of the repeater is activated. This can be easily checked on the repeater by switching from repeat to simplex mode and noting any difference in apparent received signal strength.

Desense is cured by increasing the isolation between the transmit and receive terminals. This is done by increasing the antenna separation or by adding band pass cavities, piezoelectric filters, or duplexers.

At certain frequencies, what may appear to be severe desense may be an image response to the repeater's transmit signal. The frequency of the image is dependent upon the location of the local oscillator frequency with respect to the receive signal frequency. This can be corrected by changing the frequency of either or both local oscillators, since it is possible to operate on either the plus or minus side of the signal frequency. If this should happen changing the 11.155 crystal to a 10.245 crystal will usually correct the problem. In some cases additional band pass cavities or piezoelectric filters in the antenna line may be needed.

INTERMOD (INTERMODULATION DISTORTION)

Intermod is characterized by the appearance of an unwanted or unexpected signal within the passband of the repeater receiver. One can usually identify a signal as being an intermod signal by the type of conversations taking place, by the presence of a distorted or off frequency signal, or by the presence of some signal that periodically causes the repeater to latch up. Intermod interference can be weak or strong, even to the point of covering up local signals.

Intermod interference is caused by two signals (usually strong), mixing in a non-linear circuit producing a third interfering signal. The non-linear circuit may be a transmitter output stage, a corroded antenna connector or more commonly a receiver front end.

The most common form of intermod interference is a strong signal, doubling in the receiver's mixer and mixing with a second signal to produce a product that is on or near the repeater's receive frequency. This product is commonly called 3rd order intermod. The relation between its frequency and that of the signals forming it is

$$f_{\text{IMD}} = 2f_1 - f_2; \text{ where } f_1 \text{ and } f_2 \\ \text{are the frequencies of the two signals.}$$

As an example, consider a receiver operating on 147.72 and nearby transmitters operating on 146.52 and 147.12

$$f_{\text{IMD}} = 2 \quad 147.12 - 146.52 = 147.72.$$

Since the repeater transmitter output is usually the strongest signal at the site, it's more apt to double in the receiver's mixer and cause a 3rd order intermod product with another strong in-band signal. This type of intermod is characterized by a signal which appears after the repeater is keyed up, and locks the repeater on. When the transmitter is turned off, the interfering signal goes away. This intermod interference never keys the repeater by itself.

This type of intermod can be cured by increasing the isolation between the RX and TX antenna terminals. This can be accomplished by increasing the antenna separation, installing a duplexer, or adding additional filtering in the receive line.

Intermod can also be caused by two strong signals from nearby transmitters mixing in the receiver's mixer. In this case, the interfering signal will key up the repeater. This can also be cured by adding a bandpass cavity filter, piezoelectric filter or using a bandpass - bandreject duplexer.

Intermod distortion can also occur in a transmitter output stage. This stage may be that of the repeater transmitter or a nearby transmitter. Usually the frequency doubled is the transmitter's output frequency, which together with an external signal, picked up by the transmitter antenna, forms a 3rd order intermod product. The local signals causing the intermod need to be quite strong due to the lack of gain in the transmitter's output stage.

Since this intermod product is formed outside the receiver and is within the receive band pass, it can't be filtered out in the receive antenna line. This type of interference can be eliminated by installing a circulator in the interfering transmitter's antenna line. A circulator allows power to pass in only one direction. This will prevent signals external to the transmitter from reaching its output stage.

Tracking down the cause of intermod can be a difficult or impossible task. The fact that intermod occurs is not necessarily the fault of the repeater, but is a matter of circumstances. In order for intermod to occur, there must be two signals present in some non-linear device.

In curing intermod, one simply has to remove or attenuate one of the interfering signals. Half of a solution is to find out what two signals are causing the intermod. The other half is to figure out the best way to eliminate one or both of the signals.

A good starting point is to use a good quality band pass - band reject duplexer like the VHF Engineering DPLA Series.

VHF Engineering does not market the piezoelectric filters or circulators. The filters may be obtained from:

Piezo Technology INC.
P.O. Box 7877
Orlando, Florida 32804

Circulators may be obtained from:

D B Products
P.O. Box 47128
Dallas, Texas 75247

Microwave Associates
850A Stewart Drive
Sunnyvale, CA 94086

APPENDIX D - ACCESSORY INTERFACING

Interfacing of accessories (e.g. autopatch) is the responsibility of the customer. To aid in interfacing the following terminations are provided.

(refer to rear view pictorial diagram)

- 1.) KEY - Auxiliary push to talk input. A ground will key transmitter. All timers are bypassed.
- 2.) SPKR - Speaker output for remote monitor or phone patch connection. The signal is derived from the speaker output terminal.
- 3.) SPARE - no internal connection.
- 4.) P.T.T. - auxiliary push to talk input. This terminal may be externally grounded to key the transmit section of the repeater. Timer sequencing is initiated each time this terminal is activated.
- 5.) RELAY - provides external access to a normally open contact on the COR relay which is grounded when the transmit section of the repeater is activated. The maximum current handling capability of this contact is 3 amps DC.
- 6.) +12V SEE (7)
- 7.) +12V - this terminal is connected to the output of the internal 12 volt power supply. The internal supply may be adjusted to provide a trickle charge to a storage battery connected to this point. If the power failure occurs, the battery will then become the source of power for the repeater. The maximum current output available from this terminal is 3 amps.
- 8.) GROUND

EXTERNAL AUDIO JACK - used for connection of a phone patch, external voice I.D. etc. The input audio signal is coupled directly to the transmit audio line input. Normally, a 1 volt peak to peak signal will be sufficient to produce 5KHz deviation.

APPENDIX E - SUPPLEMENTARY MANUALS

Manuals for receiver, transmitter, CWID, COR, power amplifier, and power supply models are included in this section.