

ST - 5

RTTY

DEMODULATOR

INSTRUCTION

MANUAL



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QUALITY COMMUNICATIONS EQUIPMENT

ST-5

RTTY

DEMODULATOR

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HAL ST-5 RTTY DEMODULATOR KIT

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1. INTRODUCTION

The model ST-5 RTTY Demodulator is a high-performance, all solid-state demodulator for reception of radio teleprinter signals. The ST-5 features a very high gain limiter stage capable of a 70dB dynamic range with low zero-level cross-over distortion. The discriminator circuits of the ST-5 are broad-band and linear in response throughout the required bandwidth. The linear discriminator allows reception of signals with non-standard frequency shift and assures reliable recovery of weak signals under noisy conditions. Discriminator bandwidth is switch-selectable to provide enhanced reception of the two standard frequency shifts (170 Hz and 850 Hz). A high-gain slicer stage assures that keying pulses from the solid-state keyer have the fast switching times necessary for low-distortion keying of a teleprinter. The internal power supply of the ST-5 furnishes regulated plus and minus 12 volts to operate the demodulator, and includes a 175 volt, 60 ma loop supply. A tuning meter is also furnished with the ST-5, thus reducing the number of external pieces of equipment required to receive RTTY signals. All parts necessary to construct and interconnect the ST-5 are furnished with the kit with the exception of a cabinet. The ST-5 can be installed in a user-supplied cabinet or in a Bud Minibox available separately from HAL Communications Corp.

This manual contains basic operation instructions, construction procedures, and a guide for servicing the ST-5. Please read the complete manual before beginning assembly of the ST-5.

2. SPECIFICATIONS

Input Frequency Range: 2125 - 2975 Hz (Standard)

1275 - 2125 Hz ("Low-Tones")

Input Impedance: 500 ohms, unbalanced

Limiter Performance: (at 2125 Hz)

Limiting Threshold - 1.0mV rms input

Maximum Signal Input - 3.5V rms

Discriminator Performance:

Mark Frequency, all shifts - 2125 Hz (Standard)

1275 Hz ("Low-Tones")

Space Frequency, 170 Hz shift - 2295 Hz (Standard)

1445 Hz ("Low-Tones")

Space Frequency, 850 Hz shift - 2975 Hz (Standard)

2125 Hz ("Low-Tones")

Discriminator Filter Bandwidth - 140 Hz

Minimum Usable Frequency Shift - (Standard Tones): 850 Hz - 50 Hz

170 Hz - 10 Hz

Maximum Usable Frequency Shift - (Standard Tones): 850 Hz - 1100 Hz

170 Hz - 350 Hz

Low-Pass Filter Cut-Off Frequency: 30 Hz (60 wpm, 45 baud)

50 Hz (100 wpm, 75 baud)

(Selectable by proper choice of component values)

Outputs:

LOOP: An internal 175 volt, 60 ma loop power supply is keyed by the demodulator and connected to a panel connector to which the selector magnets at the teleprinter can be directly connected.

FSK: A bi-polar keying voltage output is supplied that is EIA (RS-232) compatible. This voltage is keyed by either the demodulator itself or by interruption of the loop circuit by external devices such as a keyboard or tape transmitter. This output can be used to key an FSK circuit for transmitting RTTY or to drive the HAL RVD-1005 Solid State Visual Display System, or the HAL AK-1 AFSK oscillator.

Nominal Voltages: Mark: < -15V

Space: > +15V

KEY: A telegraph key may be connected to the FSK system to provide narrow-shift CW-ID transmission. A separate potentiometer is provided to allow adjustment of the CW shift.

SCOPE: AC voltages proportional to the signals in the discriminator filters are provided to allow use of an oscilloscope to aid in tuning the receiver. Since a tuning meter is provided with the ST-5, use of the "Scope" output is optional. Approximately 4V peak-to-peak (at the center frequency of each discriminator filter) is furnished with an internal impedance of 1 megohm.

Miscellaneous Data:

Fuse Protection: 0.5A fuse in AC power line

Power Requirement: 120/240 VAC, 50-60 Hz, \pm 10%

(Power cords are furnished for U.S. standard three-wire 120 VAC connections; other connectors must be user-supplied if required.)

Power Consumption: 14 watts maximum

Shipping Weight: 5 lbs.

3. OPERATION

The ST-5 demodulator is constructed on two printed circuit boards as is shown in the schematic diagram (Figure 1). Audio input signals are connected to jack J1 and therefore to point "A" on the demodulator board. Resistor R1 provides a 560 ohm termination for the receiver output.

If at all possible, the receiver output impedance should be matched to 500-600 ohms by either proper selection of output transformer windings or with an external voice-coil to line transformer. The ST-5 will work with audio signals from the 4-8 ohm voice-coil output, but only with the sacrifice of 30 to 40db of limiter dynamic range. Also note that resistor R1 is rated for $\frac{1}{2}$ watt; this should be quite adequate for most operations; use of more receiver output power is unnecessary and will result in damage to R1 and possibly to the limiter, OA1.

Diodes D1 and D2 in conjunction with R2 provide transient protection of the limiter operational amplifier from static bursts.

Operational amplifier OA1, a type 709 integrated circuit, serves as the limiter stage of the demodulator. Resistors R5, R7, and R8 provide adjustment of the limiter switching level for minimum distortion. Proper adjustment of R5 will be discussed in Section 5. Components C4, C5, and R11 provide extended high-frequency compensation of the 709. Components C2, R9, C3, and R10 provide power supply decoupling at the limiter.

The output of the limiter stage (pin 10, OA-1) is connected through a resistor balancing circuit (R12, R13, R14, R15) to the discriminator filters. Proper adjustment of R13 (discussed in Section 5) allows balancing of the amplitude and bandwidths of the mark and space filters of the discriminators. Capacitor C7 (with C7A) tunes L1 to the mark frequency (2125 Hz) and C8 (with C8A) tunes L2 to the space frequency (2295 Hz or 2975 Hz). Diodes D5 and D6 provide full-wave, negative detection of the mark signal and, similarly, D7 and D8 provide a positive output for a space signal. The two detector outputs are summed at pin 4 of OA2 through R21 and R22. If the two filters are balanced in both amplitude and bandwidth and the input to the demodulator is noise, equal but opposite currents are produced in R21 and R22, resulting in zero volts at pin 4 of OA2. Since noise fluctuates randomly in both amplitude and frequency, pin 4 will oscillate from plus to minus but with an average value of zero. When a signal of mark frequency (2125 Hz) is applied to the ST-5 input, D5 and D6 generate a strong negative signal that forces the input of OA2 (pin 4) negative. Similarly, a space signal (2295 or 2975 Hz) will force pin 4 positive. Thus the two filters and associated diodes provide discrimination between various audio frequencies. Proper choice of the balancing resistors R12, R13, R14, and R15 will result in a frequency to voltage response at the input of OA2 that is maximum (but of different sign) at the center frequencies of L1 and L2 and linear in response for intermediate frequencies. This linear discriminator characteristic along with the wide dynamic range of the limiter stage are the major factors in the superior weak-signal performance of the ST-5 over other demodulators.

Components R21, R22, and C17 form a simple R-C low-pass filter for the discriminated signals. If only 60 wpm (45 baud) operation is anticipated, the value of C17 should be set to .068 mfd, corresponding to a -3dB response of approximately 30 Hz. This value will give enhanced low-pass filter performance for 60 wpm, but will not allow satisfactory performance at 100 wpm. If operation at 100 wpm or both 60 and 100 wpm is anticipated, a better choice is to set C17 equal to .039 mfd, corresponding to a -3dB response of approximately 50 Hz. The change in 60 wpm performance under these conditions is slight and generally not noticeable. Moreover, equalization for 100 wpm allows compatibility with other commonly used keying speeds (60, 66, and 75 wpm) whereas the 60 wpm equalization does not.

Operational amplifier OA2, also a 709N, is used as a very high-gain slicer amplifier to "square-up" the filtered keying waveform from the discriminator. The output of the slicer (pin 10, OA2) is a square-wave with positive voltage corresponding to a mark condition and negative to space. This keying signal, through R27, switches the high-voltage keying transistor (Q2), keying the TTY loop. Diode D9 prevents negative breakdown of the 2N5655 base-emitter junction. C16 and R28 are a transient suppression network to protect Q2 from the high-voltage transients that can be induced by the selector magnets of the teleprinter.

A convenient tuning meter circuit is provided with the ST-5. Diodes D3 and D4 provide positive half-wave rectification of the mark and space signals respectively. The detected outputs are summed in the base of Q1 with C6 and R17 providing filtering of the a-c component. Transistor Q1 is an emitter-follower current amplifier that drives the meter through R16 and R18. Since both mark and space signals provide a positive current to the meter, it will always read up-scale. However, the current to the meter will be a maximum only when a signal is matched in frequency to the discriminator mark or space filters. In fact, if both the mark and space frequencies of the input signal match the discriminator tuning, the meter will have maximum deflection for both tones and will not fluctuate when the signal changes from mark to space. Therefore, correct tuning is indicated on the meter as an up-scale reading that does not change when the signal changes state. If the shift of the incoming signal does not exactly match that of the discriminator, the signal can still be tuned so that the meter does not fluctuate, but the steady reading obtained will not be as great as before since the signal has been "straddle-tuned" and is not peaked on either filter. This "plus-plus" meter signal from Q1 is also used to drive the ST-5AS Auto-start option.

Provision is also made in the discriminator circuit to use an oscilloscope as a tuning indicator. The a-c signals from each discriminator filter are connected to J5 through isolating resistors R29 and R30. If these two signals are then connected to the X and Y axis inputs of the oscilloscope, a conventional "cross-type" of RTTY tuning indicator can be used and the receiver tuned so as to maximize the signal on each axis. This technique works very well with older demodulators with sharply tuned discriminator filters and works to a limited extent with the purposely wide bandwidth discriminator filters in the ST-5. To achieve the highly desirable linear discriminator response, the ST-5 filters are considerably broader than those

constructed of tuned, but unloaded, 88 mhy toroids. The effect on the scope output is that straight, crossed lines are no longer formed, but rather, the traces are ellipses with considerable opening. These ellipses will, however, with sufficient operator experience, provide as much information regarding proper tuning with the ST-5 as with other demodulators. Also, since the ST-5 uses semiconductor devices, the scope outputs are only of the order of 4 volts peak-to-peak, thus a stage of amplification may be required in the oscilloscope.

The power supply of the ST-5 furnishes zener regulated +12 volts and -12 volts for the demodulator as well as 175 volts @ 60 ma for the TTY loop. Approximately -15 volts unregulated, partially filtered power is available at point AD for use with the ST-5AS Autostart option. It is not recommended that this point be used to power any other accessories. Sufficient additional low-voltage power capability is provided that both the ST-5AS and AK-1 options can be powered from the ST-5, but any further accessories should obtain their power from another source.

The "Mainline" floating-loop supply is incorporated in the ST-5 to produce a loop-keyed voltage (FSK output) that is negative for mark and positive for space. In mark state, Q2 is conducting and point "L" is held close to ground potential. Since there is little voltage drop in the TTY machine, point "Y", the positive terminal of the loop supply is also close to ground potential. Therefore, most of the output voltage of the loop supply (175 volts) appears across R107 and the loop current is therefore controlled by R107. The junction of R105 and R107 is therefore at approximately -155 volts and the junction of R104, R105 and R106 at approximately $\frac{1}{2}$ that, -80 volts (± 5 volts). This is further divided by R106 and R108 in parallel with any external load across Pin 3 of J2 so that approximately -15 volts is presented to a 1K load in the mark state. Conversely, if the loop is open (Q2 not conducting or machine not conducting) no current flows through R107 and point "Y" is allowed to "float-up" to the full output voltage of the unloaded loop supply, +175 volts. The divider R104-R105 and R106-R108 again reduces the voltage at the FSK output to approximately 15 volts, but this time positive. This minus to plus transition is very convenient to use to key diode-FSK circuits and is compatible with the input keying requirements of the AK-1 AFSK oscillator. This output is also compatible with RS-232 standards and can be used directly to drive the HAL RVD-1005 Visual Display System.

Another convenient feature of the FSK output of the ST-5 is that it is keyed by either the incoming signal or by the TTY keyboard. This means that if an AK-1 is connected to this point, it will regenerate an AFSK signal from the ST-5 processed incoming signal, producing a very clean output signal that could be repeated via a VHF link, etc. Conversely, if the RVD-1005 is connected to the FSK output, anything printed at the machine will be displayed on the monitor screen, be it of local-loop or off-the-air origin.

Resistor R109 and Pin 6 of J2 provide a means to use narrow-shift CW identification when a diode FSK keying circuit is used.

A special transformer that has both low-voltage and loop-voltage windings as well as a 120-240 volt primary is furnished with the ST-5 Kit. Connections for either primary voltage are shown in Figure 1.

Switch S3 allows defeat of the keyer stage, Q2, when no RTTY signals are received or when it is desired to transmit using the FSK output. A DPDT switch is furnished so that this switch could also be used to control the transmitter.

4. ASSEMBLY INSTRUCTIONS

Construction of the ST-5 will be carried out in three steps:

1. Assemble the two circuit boards.
2. Prepare a cabinet.
3. Install and interconnect the boards and connectors in the cabinet.

Before starting construction, check the parts received against the parts list. It will simplify assembly if you separate the parts by type into small boxes as you check them off the list -- that is, resistors in one box, semiconductors in another, etc.

Your kit was carefully checked for quality and completeness before shipment. Should you find any parts missing or damaged, please notify the factory in writing so that a replacement can be supplied.

Since the construction of the ST-5 involves many soldered connections, it is important that you make each one carefully. It is assumed that the builder has some prior experience in kit construction and is acquainted with good soldering practices. If not, it would be well to practice on scrap components, preferably with the help of an experienced individual, before starting work on the kit. It will also be helpful to keep the following points in mind:

1. Since most of the components are small, only a moderate amount of heat is needed to make good solder joints. Use a 15 to 25 watt iron with a pencil tip or small (1/8") chisel tip.

2. When soldering components to the printed circuit boards, avoid overheating the connections. Although high-grade epoxy-glass boards are supplied, excessive heat can cause the printed conductors to separate from the board and can also damage components. Be careful not to allow the solder to bridge between closely-spaced adjacent conductors and solder pads. Also, be careful to prevent solder splashes from falling on the board.

3. When soldering the IC socket terminal strips, be particularly careful not to use too much solder or heat. Excess solder with enough heat can be transferred through the board hole and onto the socket pins themselves.

4. If you make an error and find it necessary to remove a component from the board, heat each connection with the iron and use a suction desoldering tool or solder wicking (copper braid) to remove the excess solder. The component can then usually be lifted from the board without applying additional heat. In the case of inexpensive components, it may be better to break the component and remove the leads one at a time than to risk damaging the board by overheating it. Replacement parts may be obtained locally in most cases.

4.1 Circuit Board Assembly

Before assembling any components on the circuit boards, carefully inspect the boards themselves for defects in etching and plating. Although all boards have been inspected before shipping, it is far easier to find and correct such problems before assembly than after.

Assemble the power supply circuit board first. The power supply circuit board is the simpler of the two boards and can be further identified by the large unplated areas in the middle and near one end of the board. Refer to the layout drawing (Figure 2) and the photograph (Figure 3) for correct location of the parts on the circuit board. Note that both figures give the component-side view of the circuit board.

Orient the board as in the figures and install all circuit-board mounted resistors in the locations shown. Note that the loop resistor, R107, is NOT mounted on the circuit board. Resistor R109, the CW-Shift potentiometer, can also be mounted at this time. Solder all connections.

Install all diodes in the locations indicated, being careful to observe correct orientation. Solder all connections. Avoid excessive heat, particularly when soldering to the zener diodes, D107 and D108. The two jumpers near D107 and D108 can also be soldered-in at this time.

Finally, install the capacitors, being careful to observe electrolytic polarities. Solder all connections.

This completes the assembly of the power supply board itself. Other connections will be made upon installation in the cabinet. Inspect all solder connections and correct any defects found.

Most of the ST-5 circuitry is mounted on the remaining demodulator circuit board. This board is more complex than the power supply and great care should be taken to avoid poor solder joints, solder bridges between paths, and solder splashes. Refer to the layout drawing (Figure 4) and the photograph (Figure 5) for proper part placement.

NOTE: If the ST-5 is to be used with the ST-5AS Autostart Kit, refer to page 4 and Figures 4A and 4B of the ST-5AS manual for modifications required to the ST-5 demodulator circuit board. As is shown in Figure 4B (of the ST-5AS manual), it is necessary to cut one path on the ST-5 demodulator board to use the autostart option. Use a sharp knife or scribe to cut a 1/16" wide opening in the path indicated. If the ST-5 is not being constructed with the autostart, do not make this modification as it can be done later if desired.

The two integrated circuits should be installed on the circuit board first. Supplied in the kit are four seven-pin socket strips. DO NOT separate the pins from the carrier strip before soldering them in place. A simple technique to hold the strips in the proper position for soldering is to first install the strips on the IC's and then insert the pins into the circuit board. Solder all pins to the circuit board, observing the precautions

mentioned earlier. AFTER SOLDERING, remove the carrier strips from the tops of the pins by firmly gripping the strip with long-nose pliers and gently bending the strip away from the IC. There is a preformed indentation along the carrier at each pin so that it will snap-off without too much force. Be careful not to bend any of the terminals when removing the carriers. Be sure that the integrated circuits are oriented as shown in the figures. If they have been installed backwards, pull the circuit from the socket and turn it around.

Additional pads are provided so that the round, T0-5 packaged 709 IC can be used if desired. Since the kit is normally supplied with 14 pin DIP IC's, these extra holes are usually not used.

Install all resistors, potentiometers, and diodes in the positions shown. Note that all the resistors and diodes are mounted in a vertical position. Be careful to observe proper diode polarity. Also, install the wire jumpers at this time. Solder all connections.

Install both transistors and solder all connections. Be sure that the leads are correctly oriented.

Install all capacitors in the locations shown. Solder all connections. Capacitor locations C7A, C8A, and C9A are provided for additional tuning capacitors if needed.

Finally, install the two 88 mHy toroidal coils, being careful to connect the leads as shown. See Figures 6 and 7 for connection and mounting details. Strip enamel from the wires and solder to points indicated in Figure 4.

This completes the assembly of the demodulator board. Other connections will be made upon installation in the cabinet. Inspect all solder connections and correct any defects found.

4.2 Cabinet Preparations

In the interest of economy, no special cabinet is provided for the ST-5 kit. The kit builder is therefore free to choose whatever housing best matches his equipment and is most convenient for his station. A popular housing for the ST-5 is the BUD CU2110A Minibox which is available from HAL Communications. Whether the BUD box or other housing is used, a few general guidelines are in order:

1. Resistor R107 dissipates 9.9 watts during mark condition and should therefore be mounted away from other parts. A satisfactory mounting is on a terminal strip, vertically positioned on either the front or rear panel.
2. Place switches S1 (Shift), S2 (Power), and S3 (Receive-Standby) as well as the pilot lamp and the meter on the front panel. The connectors and line cord should be placed on the rear panel.
3. It is wise to leave space for the ST-5AS and AK-1 options even if they are not used initially. You may or may not wish to put in extra holes for the connectors and switch associated with these options.

4. For those who wish to use the Bud box, a suggested cabinet layout and drilling guide are shown in Figure 6. When the ST-5, ST-5AS, and AK-1 kits are installed as shown, the cabinet is crowded and you may wish to consider a different layout and/or a larger box. This layout requires that the edge connector fingers on the AK-1 be sheared off and wire connections be made directly to the circuit board.

4.3 Installation and Interconnection in the Cabinet

These steps will, of course, vary somewhat with the cabinet layout chosen, but a few more general points are worth consideration.

Terminal strips are provided to mount the loop resistor (R107) and for connections to the AC power cord. When connecting the AC power cord, be sure that the green wire connects directly to chassis ground and that the black wire connects to the fuse first and then to the AC power switch and then to the power transformer. The white wire should connect directly to the power transformer as shown. The AC power cord should be by-passed (C106 and C107) immediately after it enters the cabinet to minimize potential stray RF interference. Be sure to connect the dual primaries of the power transformer as shown for your power line voltage.

The leads to the input connector and the scope connector (as well as the audio output leads from the AK-1, if used) should be made with miniature shielded cable if they must be more than four inches long.

When interconnecting the boards and cabinet-mounted parts, it is wise to leave enough wire length that each board can be sufficiently removed from the cabinet for maintenance. Lead lengths should not in general be critical.

5. TEST AND ALIGNMENT

After the ST-5 has been completely assembled, double-check all wiring to make sure there are no errors. Particularly make sure that the ac power, loop supply, and low voltage supplies are correctly connected.

5.1 Preliminary Power Supply Tests

CAUTION: IN THE FOLLOWING STEPS, POTENTIALLY LETHAL VOLTAGES ARE EXPOSED IN THE CABINET WIRING. BE VERY CAREFUL WHEN MAKING MEASUREMENTS TO AVOID TOUCHING EXPOSED TERMINALS.

Put a $\frac{1}{2}$ ampere fuse in the fuse holder and plug the line cord into a grounded three-prong ac power outlet (or suitable power source if using 220 VAC.)

DO NOT DEFEAT THE GROUNDING PLUG FEATURE. TO DO SO COULD PRESENT A SHOCK HAZARD, LEAD TO RF INTERFERENCE PROBLEMS, AND WILL VOID ANY WARRANTY BY HAL COMMUNICATIONS.

Turn the AC Power switch on. The pilot lamp should light. Make the following voltage measurements in the ST-5 using a 20,000 ohms-per-volt VOM:

1. Measure 115 VAC between terminals 1 and 2 and between terminals 3 and 4 of the power transformers. These measurements will be the same for either 115 or 230 VAC power input connections.
2. At point "K" on the demodulator board, measure +12 VDC, ± 1.2 volts.
3. At point "H" on the demodulator board, measure -12 VDC, ± 1.2 volts.
4. With switch S3 in "Standby" position and a jumper between pins 4 and 1 of J2, measure approximately -155 VDC ($\pm 10\%$) across the loop resistor, R107.
5. Remove the jumper from pins 4 and 1 of J2 and measure approximately +170 VDC ($\pm 10\%$) at point "Y" on the power supply board.
6. At point "AD" on the power supply board, measure approximately -20 VDC ($\pm 15\%$).
7. Turn the power switch off.

If the previous voltage measurements check, proceed to the next step. If they do not check-out, a wiring error has been made and should be corrected before continuing.

5.2 Alignment of the ST-5

Short the audio input to the ST-5 (jack J1), turn-on the power, and measure the DC voltage at pin 10 of IC 0A-1. Adjust potentiometer R5 to obtain as close as possible to zero volts at pin 10. Since 0A-1 is connected for very high gain, it may not be possible to adjust R5 for exactly zero volts.

Remove the short from J1 and connect an audio oscillator to J1. The oscillator should be capable of approximately 1.0 volt rms output in the 1.0 to 3.0 kHz frequency range. Adjust the oscillator frequency and note the readings on the tuning meter. With the Shift Switch (S1) set for 850 Hz, the meter reading should peak at approximately 2.1 and 3.0 kHz. Set the oscillator frequency to the meter peak near 2.1 kHz. Adjust potentiometer R18 to give a meter reading of 0.7 ma. Change the oscillator frequency to get a meter peak reading near 3 kHz. Adjust potentiometer R13 to again get a meter reading of 0.7 ma.

Connect a 0 to 100 ma meter (or VOM on the 100 ma scale) between pins 4 and 1 of a 6 pin connector with the positive lead to pin 1 and the negative lead to pin 4. Turn the ST-5 off and wait 30 seconds to assure that the filter capacitors have discharged. Insert the plug into J2. Turn the ST-5 back on. With the signal generator frequency set below approximately 2400 Hz, the meter should indicate a loop current of 60 ± 10 ma. When the generator frequency is above 2600 Hz, the loop current should be zero.

The discriminator tuned circuits can now be adjusted. Connect a frequency counter or other accurate frequency measuring device to the audio oscillator. Since the discriminator tuned circuits have a relatively wide bandwidth, measurement of the frequency corresponding to a peak tuning meter reading is difficult. A much more accurate technique is to measure frequencies on either side of the peak and calculate the mid-point. For example, to measure the center frequency of the mark circuit, first make sure that the peak meter reading is approximately 0.7 ma. Next, adjust the oscillator frequency up in frequency until a meter reading of 0.6 ma is obtained. Record this frequency. Adjust the oscillator down in frequency, past the peak, until the lower frequency corresponding to a meter reading of 0.6 ma is obtained. Record this frequency. The center frequency can now be determined by adding the two frequencies and dividing by two. Use this technique to measure all center frequencies.

With the shift switch in the 850 Hz position (switch S1), measure the mark frequency. The measured frequency will generally be below the desired 2125 Hz mark frequency. If so, adjust the tuning by removing turns from L1 at the approximate rate of 3 Hz per turn removed. DO NOT attempt to make large frequency adjustments in one step. Rather, remove almost enough turns and then remeasure the center frequency; it is far easier to remove additional turns than to put some back on the toroid. If more than 10 turns must be removed from a toroid, remove an equal amount from each half to maintain the detector balance. If the original center frequency is higher than 2125 Hz, lower the resonant frequency by adding capacitance at location

C7A at the rate of 2 Hz per 100 pf added. After the mark circuit has been set to a center frequency of 2125 Hz, recheck the adjustment of R18 and re-adjust if necessary.

Next, change the signal generator frequency to give a peak meter indication near 3 kHz. Readjust R13, if necessary, to give a meter reading of 0.7 ma. As before, compute the space circuit center frequency by measuring the frequencies corresponding to a 0.6 ma meter reading. This circuit will generally be tuned higher than the desired 2975 Hz center frequency. If so, lower the resonant frequency by adding capacitance at location C8A at the rate of 5 Hz per 100 pf added. If the frequency must be increased, remove turns from L2 at the rate of 5 Hz per turn removed, again being careful to avoid removing too many turns. When the center frequency has been adjusted, the 850 Hz shift mode is now aligned.

To align the 170 Hz shift mode, switch S1 to 170 Hz and tune the oscillator to the mark frequency, 2125 Hz. Since the same tuned circuit is used for both 170 and 850 Hz shift, the mark circuit should already be aligned. Note the tuning meter reading at the peak for the mark frequency. It may or may not be equal to 0.7. If not, adjust R18 to give a 0.7 ma meter indication. Next, locate the center frequency of the space circuit and adjust R13 for a meter reading of 0.7 ma. As before, compute the center frequency and adjust ONLY the capacitor to get a center frequency of 2295 Hz. Additional capacitors, if needed, can be placed at location C9A. If it is necessary to adjust L2, the alignment of the 850 Hz space circuit must be repeated since this toroid is common to both 170 and 850 Hz space filters. Adjustment factors are the same as for 2125 Hz, 2 Hz per 100 pf or 3 Hz per turn.

Note: Because the same tuned circuit is used for both the 170 Hz and 850 Hz space filters, potentiometers R13 and R18 can only be set exactly for one or the other shifts. It is suggested that they be adjusted for the more critical operations at 170 Hz shift as a final alignment step. As discussed before, set R18 first for 0.7 ma meter reading at 2125 Hz (mark) and then R13 for 0.7 ma at 2295 Hz (space).

Alternate Low-tone Alignment

Measure frequencies and adjust as described above, except the frequencies should be 1275 Hz for mark and 1445 Hz for 170 Hz shift space and 2125 Hz for 850 Hz space. Be sure to use the alternate values for C7, C8, and C9 as well as for R12, R14, R15, and R22 described in note 3 in Figure 1.

The alignment and adjustment of the ST-5 is now complete.

6. INTERCONNECTION OF THE ST-5 TO OTHER EQUIPMENT

The ST-5 is now ready to be connected to other equipment in the station. Mating plugs are provided for all external connections. Use shielded cable where possible to avoid potential stray-RF interference problems.

6.1 Printer Connection

Refer to Figure 7 and connect the printer to pins 4 and 1 of a 6-pin plug as shown. Note that the ground contact (pin 5) of the plug is NOT part of the loop circuit, although it can be used for a shield connection to ground if shielded cable is used. The selector magnets should be wired in series with the keyboard contacts AT THE MACHINE to permit local-loop operation using the ST-5 internal loop supply. Make sure that none of the loop connections to the teleprinter are connected to the machine frame or any other ground source. Also, be sure that all internal loop supplies in the machine are disconnected.

6.2 Audio Input Connection

As shown in Figure 7, connect a shielded cable between the receiver audio output and a phono connector. It is highly recommended that the 500 to 600 ohm output of the receiver be used if available. If this output is not available, the ST-5 will work when driven from a 4 to 8 ohm voice coil output, but at the sacrifice of 30 to 40 dB of limiter dynamic range. A step-up transformer can be used to transform the low impedance output up to 500 ohms.

6.3 Oscilloscope Connection

If desired, an oscilloscope can be connected for use as a tuning indicator. Make the connection with a short (less than 3 ft.) length of two-conductor, shielded cable with the plug wired as shown in Figure 7. As discussed earlier in Chapter 3, the voltage available for the oscilloscope is only of the order of 4 volts peak-to-peak and amplification in the oscilloscope may be necessary to produce a satisfactory pattern.

6.4 Other Connections

The FSK Keying output of the ST-5 can be used for several purposes such as driving a diode FSK circuit, providing data output to the HAL RVD-1005 Visual Display Unit, or keying the HAL AK-1 AFSK Oscillator. Always use shielded cable when using this connection.

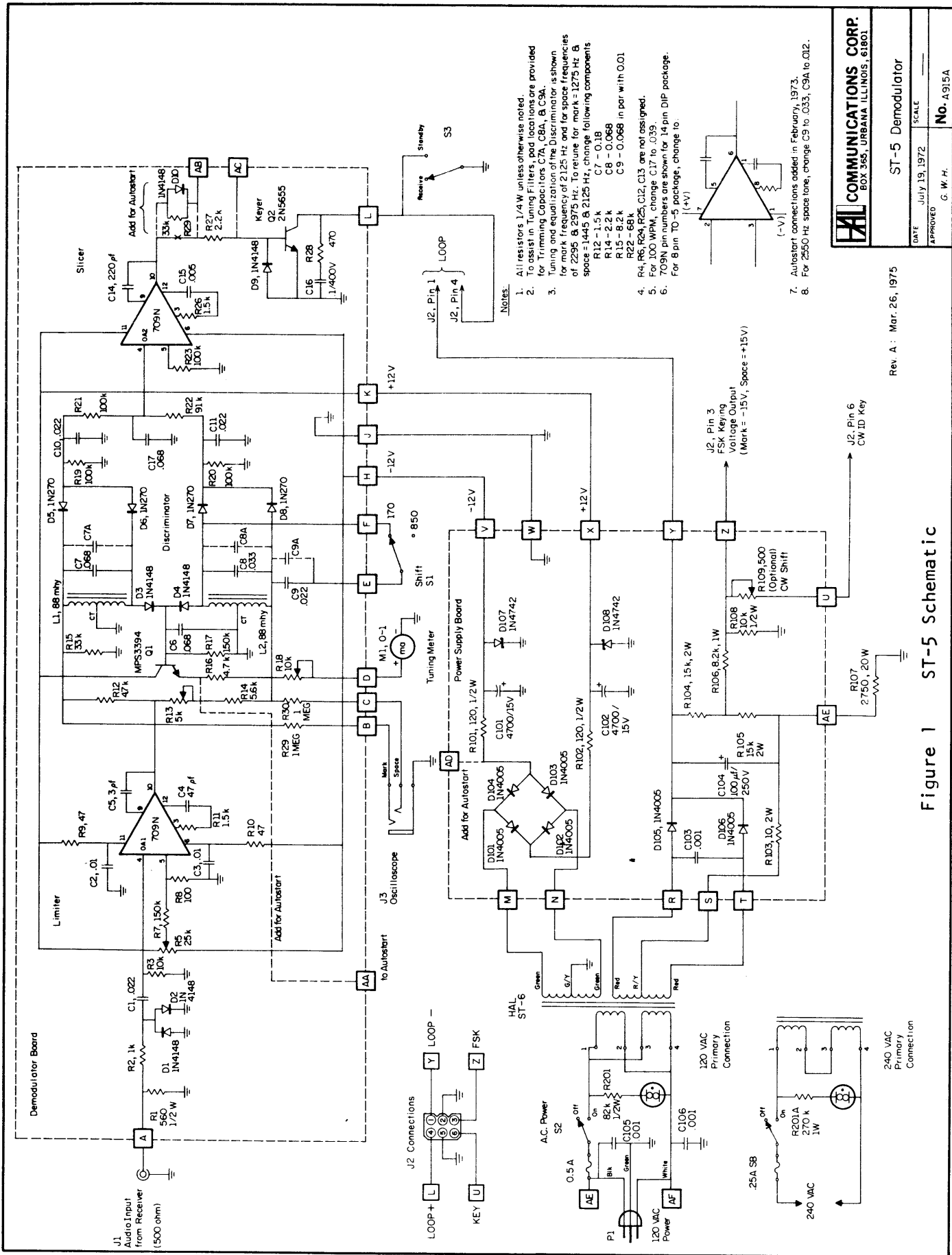
The CW ID Key jack is only useful when the FSK jack is used to drive a diode FSK circuit, although when the ST-5 and AK-1 are combined, this jack is also connected for the CW ID Key in the AFSK mode. See the AK-1 manual for further information.

For connections to or from the AK-1 and/or the ST-5AS options, the pertinent manual should be consulted for proper connections.

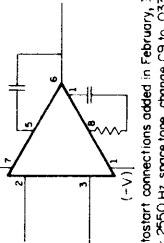
A typical RTTY station with the ST-5 and other equipment is shown in Figure 8.

7. SCHEMATIC AND WIRING DIAGRAMS

The schematic, circuit board layouts and photographs, and wiring diagrams are shown on the following pages.



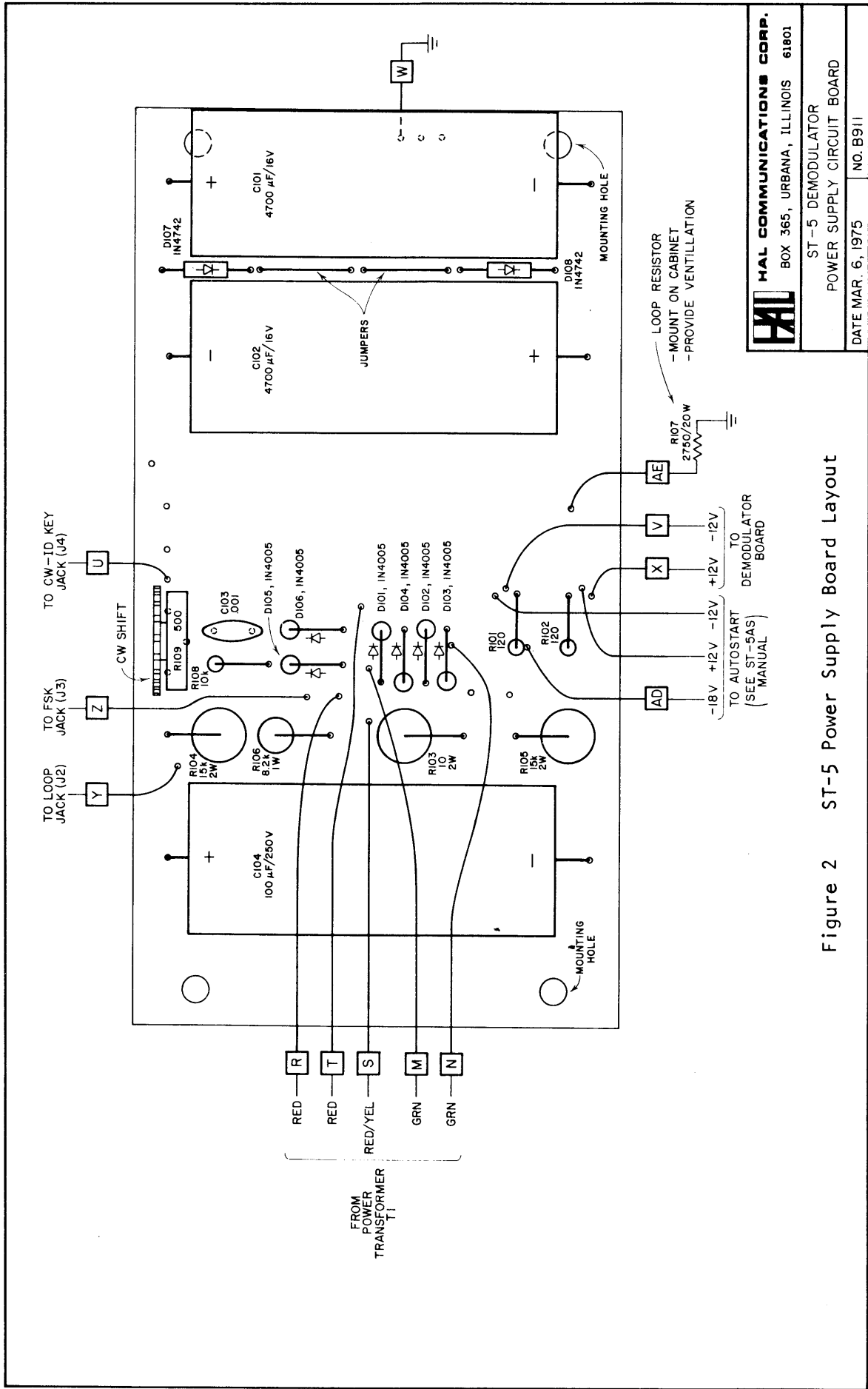
- Notes:
1. All resistors 1/4 W unless otherwise noted.
 2. To assist in Tuning Filters and Isolators provided for Trimming Capacitors C7, C8A, B, C9A.
 3. Tuning and equalization of the Discriminator shown for mark frequency of 2125 Hz and for space frequencies of 2295 & 2975 Hz. To return for mark = 1275 Hz. & space = 1445 & 2125 Hz, change following components:
 - R12 - 1.5k
 - C7 - 0.18
 - R14 - 2.2k
 - R15 - 82k
 - R22 - 82k
 4. R4, R6, R25, C12, C13 are not assigned.
 5. For 100 WPM, change C17 to .035.
 6. 709N pin numbers are shown for 14 pin DIP package. For 8 pin TO-5 package, change to:
 - R12 - 1.5k
 - C7 - 0.18
 - R14 - 2.2k
 - R15 - 82k
 - R22 - 82k
 7. Autostart connections added in February, 1973.
 8. For 2550 Hz space tone, change C9 to .033, C9A to .022.



Rev. A : Mar. 26, 1975

Figure 1 ST-5 Schematic

		ST-5 Demodulator	
		DATE July 19, 1972	SCALE
APPROVED		G. W. H.	
		No. A915A	



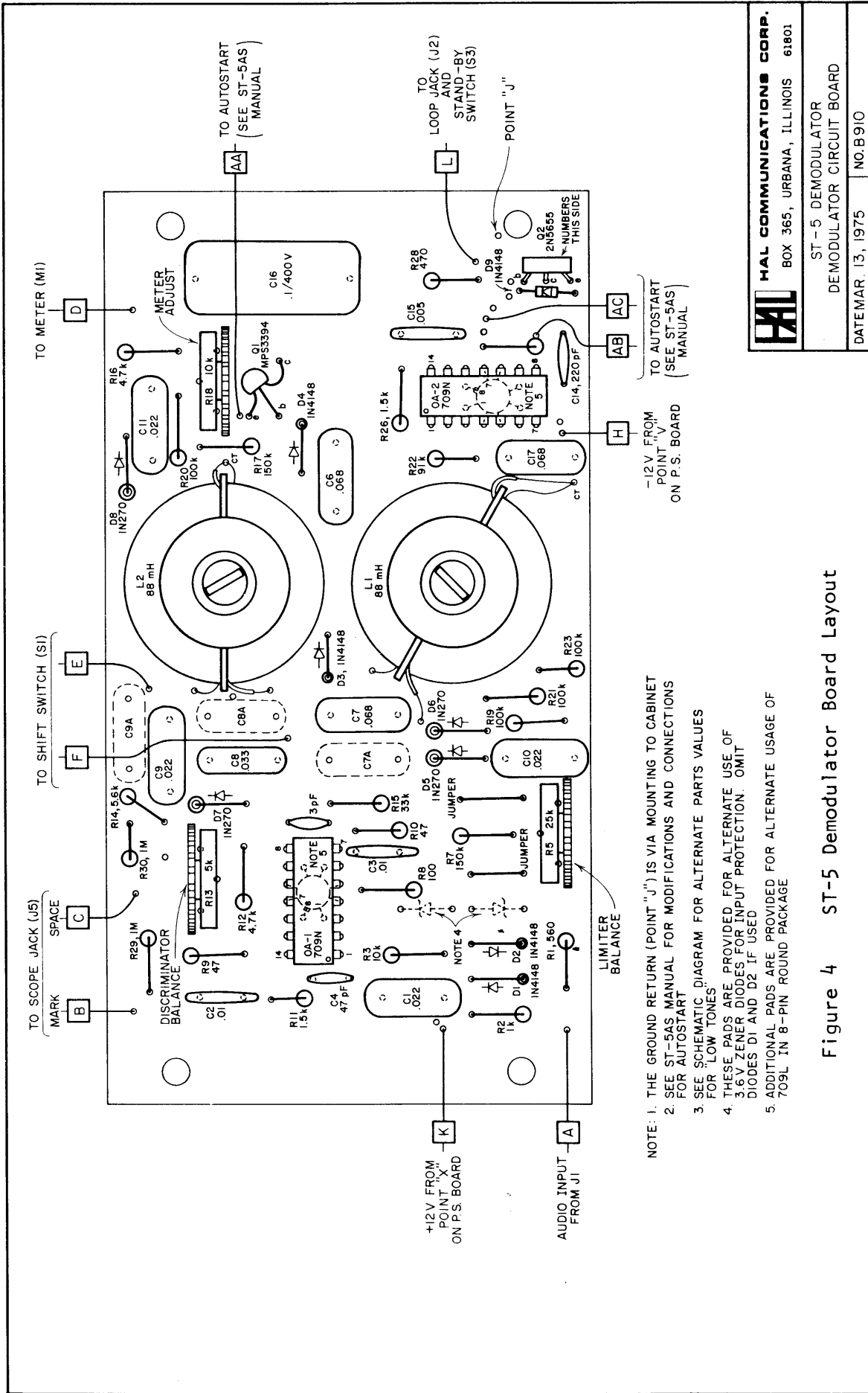
HAL HAL COMMUNICATIONS CORP.
BOX 365, URBANA, ILLINOIS 61801

ST-5 DEMODULATOR
POWER SUPPLY CIRCUIT BOARD
DATE MAR. 6, 1975 NO. B911

Figure 2 ST-5 Power Supply Board Layout



Figure 3 ST-5 Power Supply Board



- NOTE: 1. THE GROUND RETURN (POINT "J") IS VIA MOUNTING TO CABINET
 2. SEE ST-5AS MANUAL FOR MODIFICATIONS AND CONNECTIONS FOR AUTOSTART
 3. SEE SCHEMATIC DIAGRAM FOR ALTERNATE PARTS VALUES FOR "LOW TONES"
 4. THESE PADS ARE PROVIDED FOR ALTERNATE USE OF 3.6V ZENER DIODES FOR INPUT PROTECTION. OMIT DIODES D1 AND D2 IF USED
 5. ADDITIONAL PADS ARE PROVIDED FOR ALTERNATE USAGE OF 709L IN 8-PIN ROUND PACKAGE

Figure 4 ST-5 Demodulator Board Layout

HAL HAL COMMUNICATIONS CORP.
 BOX 365, URBANA, ILLINOIS 61801

ST-5 DEMODULATOR
 DEMODULATOR CIRCUIT BOARD
 DATE: MAR. 13, 1975 NO. B910

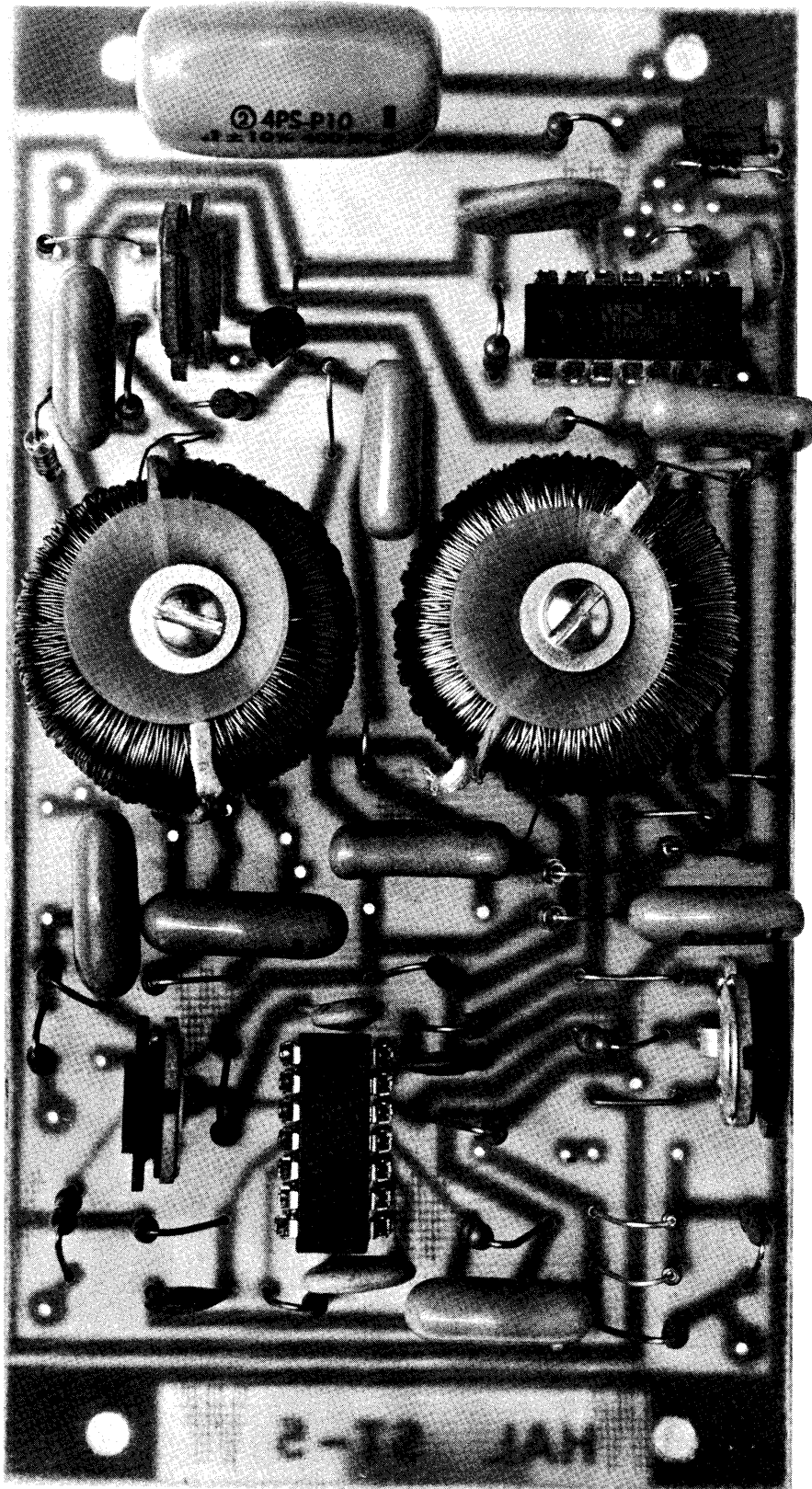
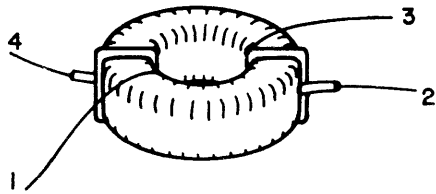
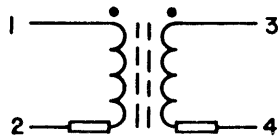
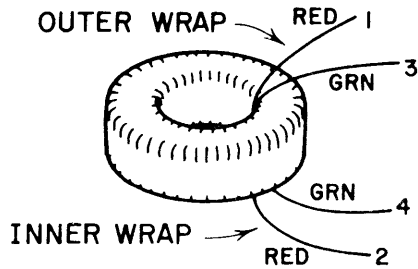
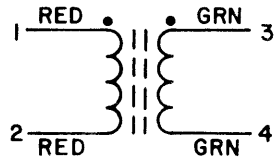


Figure 5 ST-5 Demodulator Board

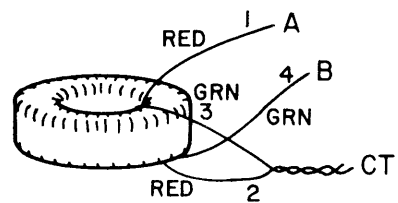
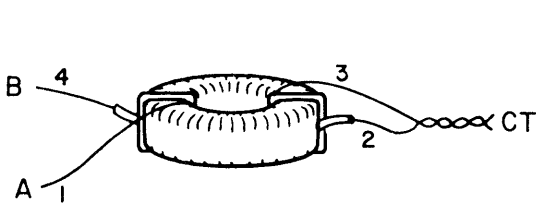
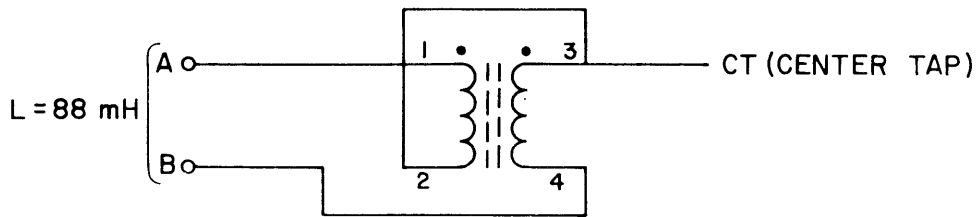
STANDARD



MULTICOLOR



SERIES CONNECTION, 88 mH



PARALLEL CONNECTION, ~22 mH

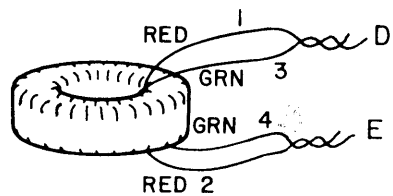
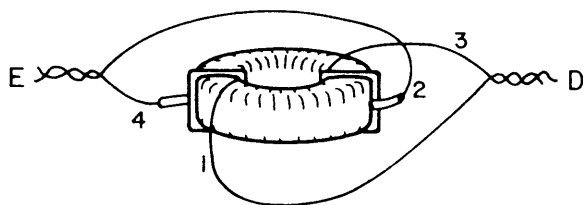
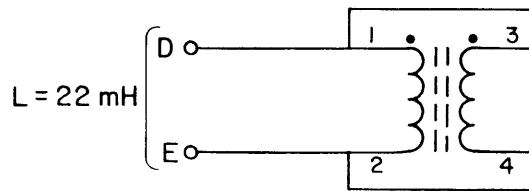
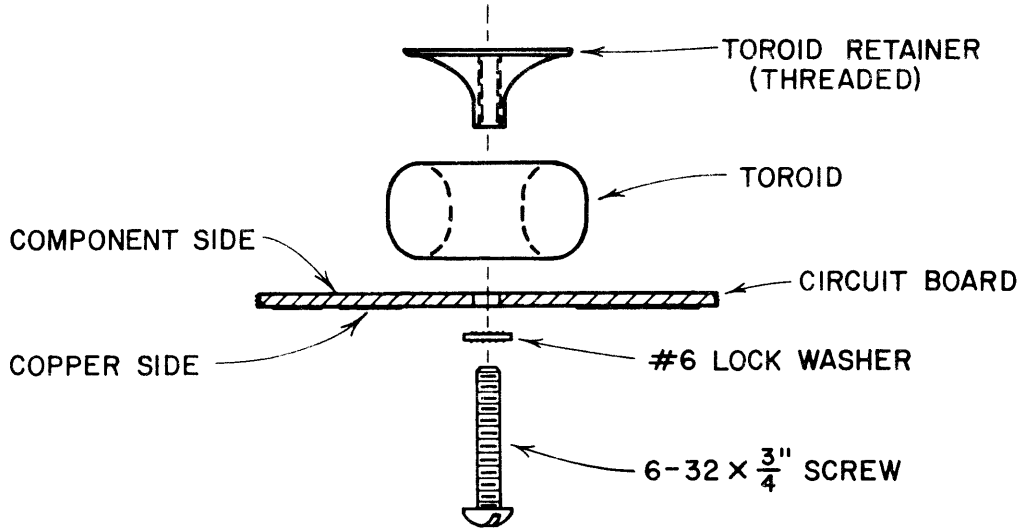


Figure 6 Toroid Wiring

SINGLE TOROID



STACKED TOROIDS

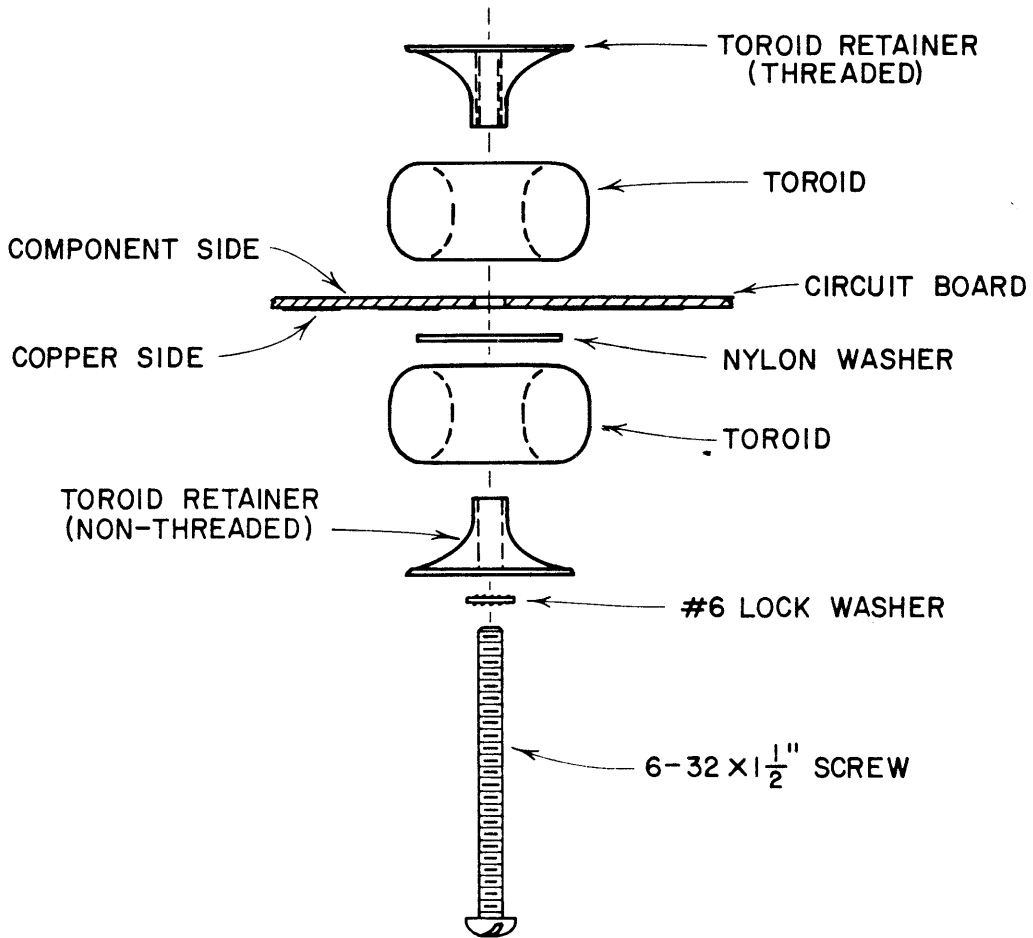
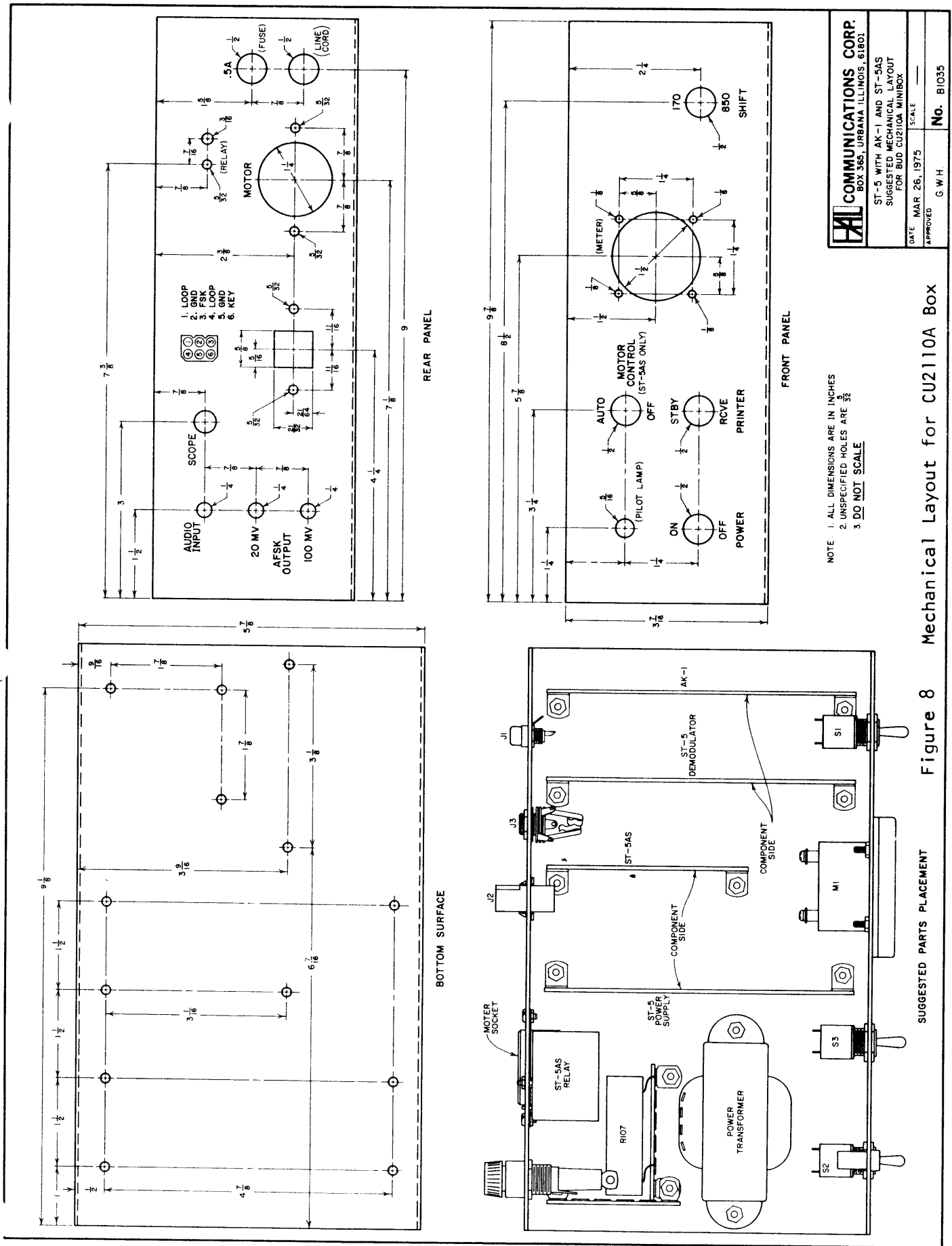


Figure 7 Toroid Mounting



FAI COMMUNICATIONS CORP.
 BOX 368, URBANA, ILLINOIS, 61801

ST-5 WITH AK-1 AND ST-5AS
 SUGGESTED MECHANICAL LAYOUT
 FOR BU2 CU2110A MINIBOX

DATE: MAR 26, 1975
 APPROVED: G.W.H.
 SCALE: _____
 No. BI035

NOTE: 1. ALL DIMENSIONS ARE IN INCHES
 2. UNSPECIFIED HOLES ARE $\frac{3}{32}$ "
 3. DO NOT SCALE

Figure 8 Mechanical Layout for CU2110A Box

SUGGESTED PARTS PLACEMENT

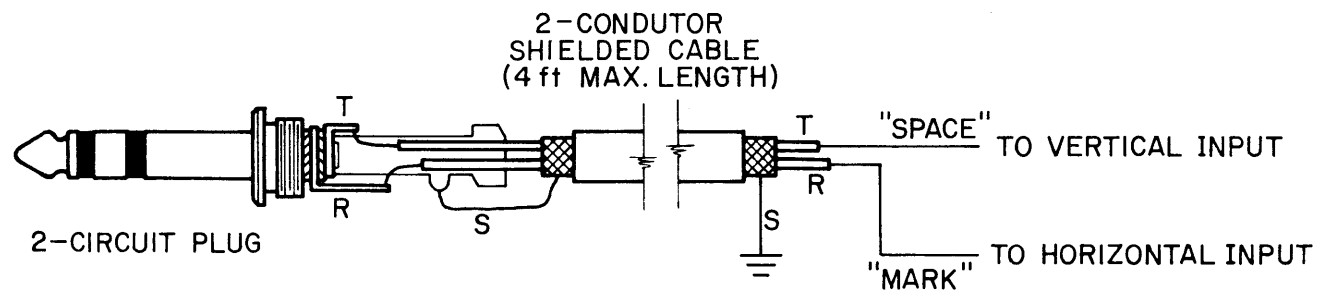
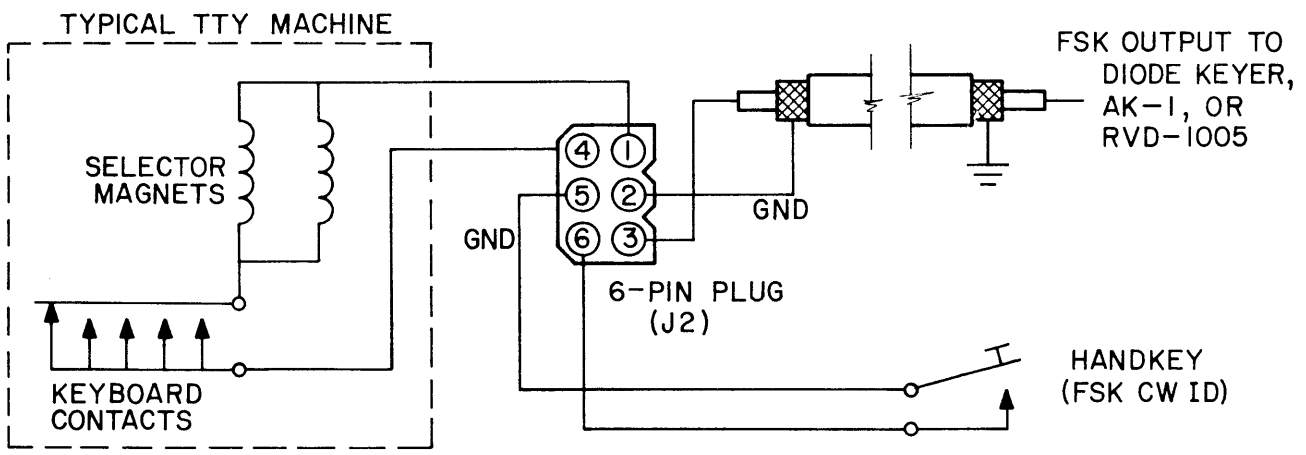
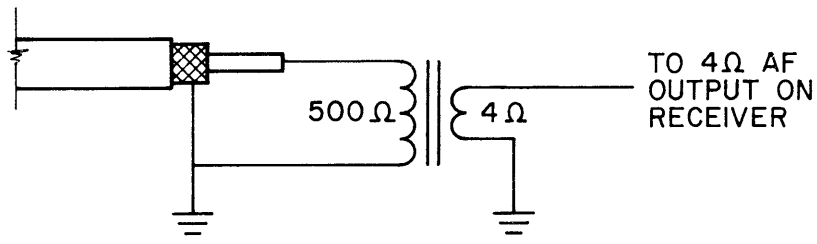
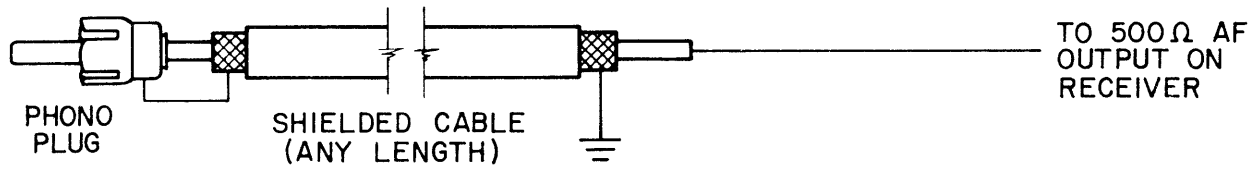


Figure 9 Plug Connections

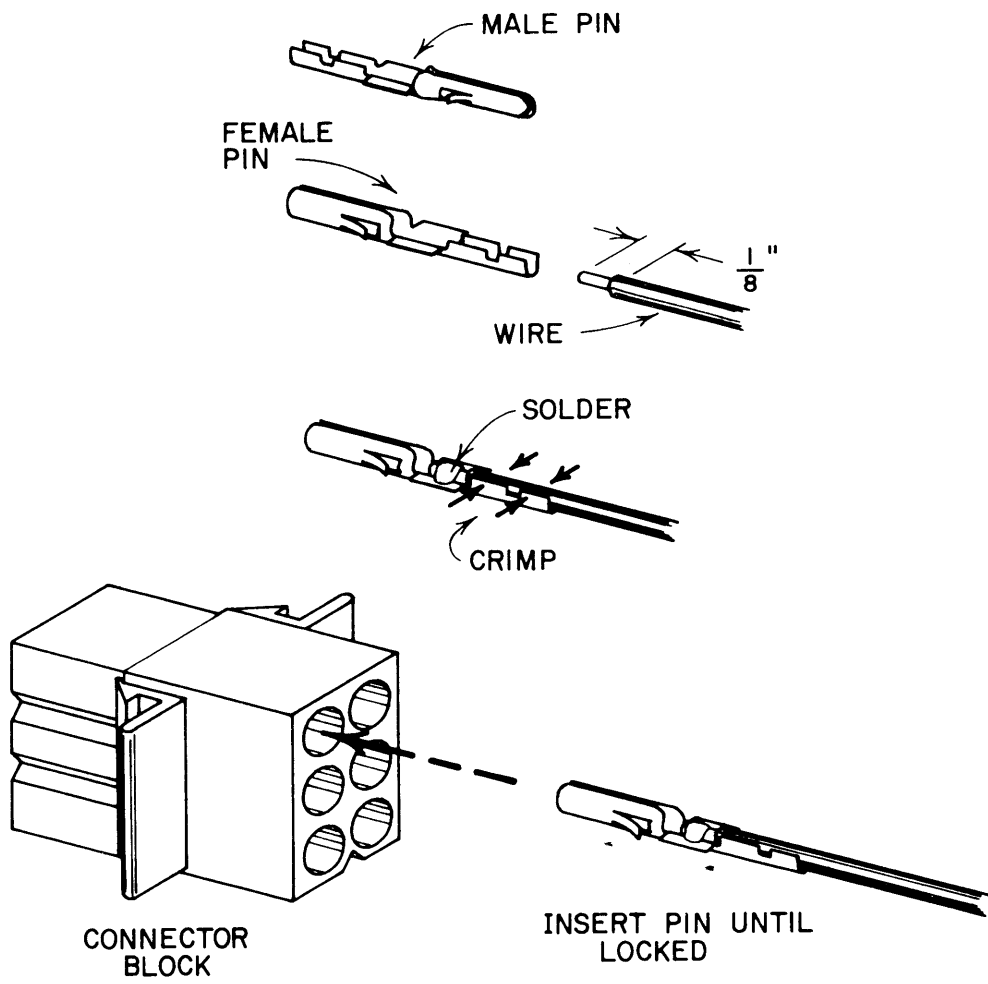


Figure 10 Loop Plug Preparation

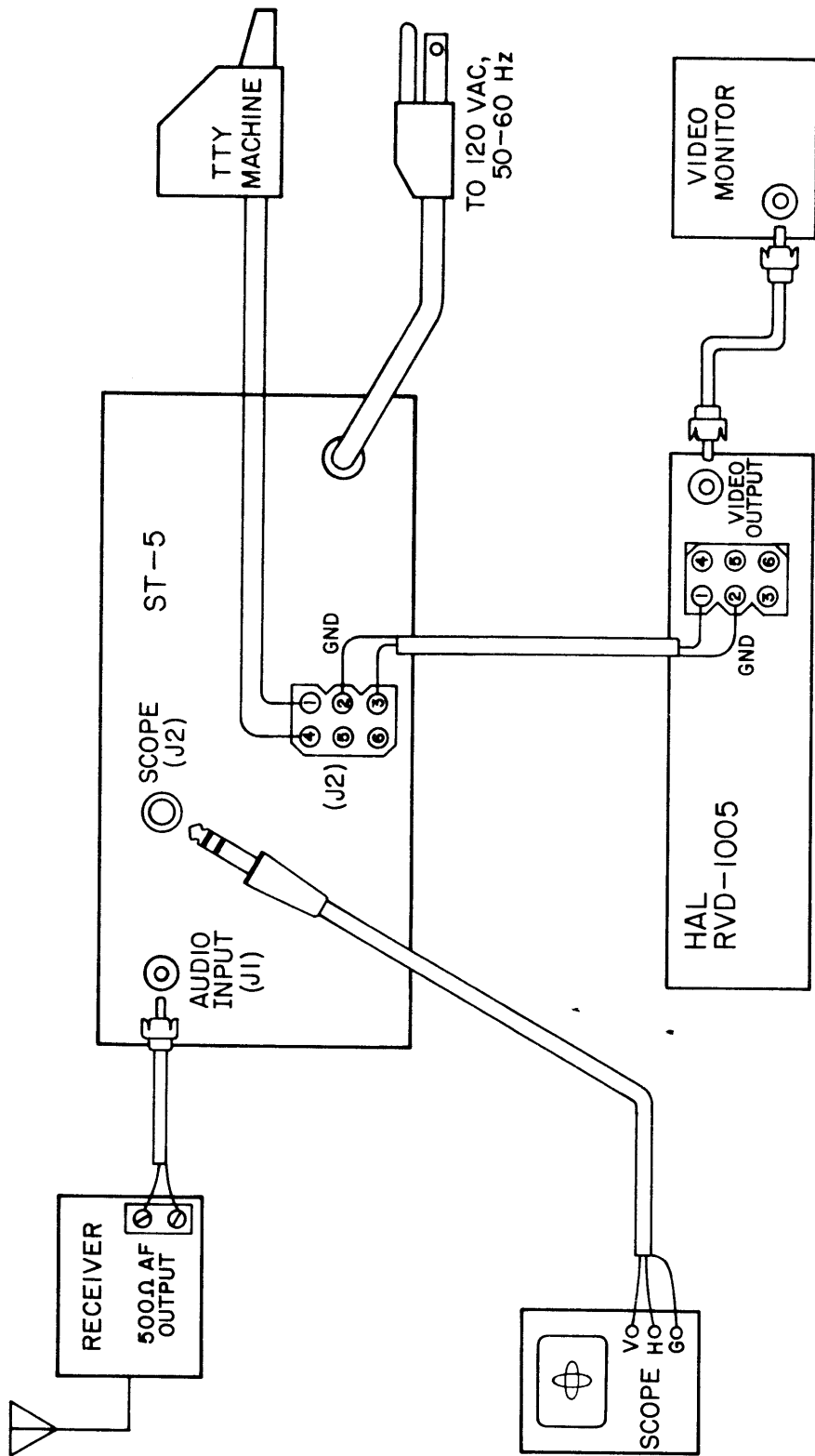


Figure 11 Interconnection to Other Equipment

PARTS LIST ST-5

Resistors (1/4 watt unless noted)

()	2	47
()	1	100
()	2	120 (1/2 w)
()	1	470
()	1	560
()	1	1K
()	2	1.5K
()	1	2.2K
()	2	4.7K
()	1	5.6K
()	2	10K
()	1	33K
()	1	82K (1/2 w)
()	1	91K
()	4	100K
()	2	150K
()	2	1Meg
()	1	8.2K (1 watt)
()	1	10 ohms (2 watt)
()	2	15K (2 watt)
()	1	500 ohm trimpot
()	1	5K trimpot
()	1	10K trimpot
()	1	25K trimpot
()	1	2750 ohm (20 watt)

Capacitors

()	1	3pf disc
()	1	47 pf disc
()	1	220 pf disc
()	3	.001 uf disc
()	1	.005 uf disc
()	2	.01 uf disc
()	4	.022 O.D.
()	1	.033 O.D.
()	3	.068 O.D.
()	1	.1 uf 400 VDC O.D.
()	1	100 uf 250 VDC electrolytic
()	2	4700 uf 15 VDC electrolytic

Semiconductors

()	2	709
()	1	2N5655 or MJE340
()	1	MPS3394
()	4	1N270
()	5	1N4148
()	6	1N4005
()	2	1N4742

Miscellaneous

()	2	88 mhy toroid
()	2	SPST toggle
()	1	DPDT toggle
()	1	500 ma (1/2A) fuse
()	1	strain relief
()	1	phono jack
()	1	phono plug
()	1	6 pin socket
()	2	6 pin plugs
()	6	Female pins
()	12	Male pins
()	1	stereo phone jack 1/4"
()	1	stereo phone plug
()	2	Toroid retainers
()	2	6-lug terminal strip
()	4	angle brackets
()	2	6 - 32 x 3/4" screw
()	16	6 - 32 x 3/8" screw
()	16	6 - 32 locknuts
()	4	7 pin IC socket strips
()	1	neon lamp assembly
()	1	fuseholder
()	2	#6 ground lugs

ST-5 Boxing

()	1	Board Set
()	1	Meter
()	1	ST-6 transformer
()	1	Line cord
()	1	Manual
()	25 ft.	Hook-up wire

HAL COMMUNICATIONS CORP
P.O. BOX 365
URBANA, IL 61801

LIMITED WARRANTY

HAL Communications Corp of Urbana, Illinois, hereby warrants to the original purchaser only that any new equipment manufactured by HAL Communications Corp shall be free from defects in materials and workmanship for a period of one year from the date of original purchase. In the case of parts kits, this warranty applies only to materials and not to workmanship in kit assembly.

In the event of a defect in materials or workmanship during the warranty period, HAL Communications Corp will, at its own expense, repair the defective unit and replace any defective parts. Costs of shipping the unit to HAL Communications Corp shall be paid by the purchaser, as well as costs of removal and reinstallation of the unit. HAL Communications Corp will bear the shipping costs incurred in returning the unit to the purchaser.

To obtain service under this warranty, the original purchaser should do the following:

1. Notify, as soon as possible, the Customer Service Department at HAL Communications Corp, Urbana, Illinois, either in writing or by telephone, of the existence of a possible defect;
2. At the time of notification, identify the model or serial number, the approximate date of purchase, the place of purchase, and the possible defect;
3. Hold the unit until a written return authorization is received.
4. Return the unit, freight prepaid, upon the receipt of the written return authorization.

Correct installation, use, maintenance, and repair are essential for proper performance of this product. The purchaser should carefully read the technical manual.

This warranty does not apply to any defect which HAL Communications Corp determines is due to any of the following:

1. Improper maintenance or repair, including the installation of parts or accessories that do not conform to the quality and specifications of the original parts;
2. Misuse, abuse, neglect, improper installation, or improper operation (including operation without a proper safety ground connection);
3. Accidental or intentional damage.

All implied warranties, if any, are limited in duration to a period of one year from the date of original purchase. Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.

HAL Communications Corp disclaims any liability for incidental or consequential damages arising out of the use of, or inability to use, this product. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.