

ST-6 RTTY
DEMODULATOR

INSTRUCTION
MANUAL



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QUALITY COMMUNICATIONS EQUIPMENT

ST-6 RTTY

DEMODULATOR

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ST-6 MANUAL CHANGES

IMPORTANT: Do not work with either the ST-6 kit or wired unit before making these changes!

The following changes in the ST-6 manual apply to wired units with serial number 757 and higher and ST-6 kits shipped after July 25, 1975. These changes are:

1. The 2500 ohm loop pot is no longer available. A fixed, 2750 ohm, 20 watt resistor is supplied that replaces both the loop pot (R6) and its series 500 ohm, 5 watt resistor (R5). These changes are reflected in the new pages supplied.
2. Improved toroid mounting hardware is now furnished with all wired and kit ST-6 demodulators. The proper assembly with these retainers is shown in the new Figure 3A attached. The "Single Toroid" detail should be used when attaching toroids to the 1-170 and the 1-850 circuit boards. The "Stacked Toroid" detail should be used in the construction of the 2-170, 2-425, and 2-850 circuit boards. Note that the black retainers are threaded and the white retainers are not. The white retainers are only used to secure one of the two toroids on the No. 2 circuit boards. The black retainers are used for the other toroid on the No. 2 boards as well as for all toroids on the No. 1 boards. Also, to minimize confusion, the wiring of the toroids is detailed in the new Figure 3B attached. The "Series Connection" detail should be used in construction of all but the 1-170 circuit board. Use the "Parallel Connection" detail when constructing the 1-170 circuit board. Make the following changes in the manual text:

Page 16: Delete paragraph 6 and replace it with:
"Refer to Figure 3A for the proper technique to use in mounting the toroids to the circuit boards. The wiring is shown in Figure 3B."

Page 17: Delete the first two sentences of paragraph 1 and replace them with:
"Refer to Figure 3A ("Stacked Toroid" detail) for the proper mounting technique for the two toroids. The wiring is shown in Figure 3B ("Series Connection" detail).

Additional changes are reflected in the new pages supplied.

3. The rear panel connections for the LOOP, KEY, FSK, REMOTE, and SCOPE functions have been changed from the phone jacks formerly used to multiple contact connectors. This change has been made to eliminate the possibility of exposed high voltages that could result if a connector is removed from the ST-6 before an external

device is turned off. The change also assures compatibility of the ST-6 with other HAL RTTY equipment. The use of the multiple contact connector for the loop connection also allows more than one RTTY device to be connected to the ST-6. The new pages supplied reflect these changes.

4. There are some errors in Figure 13, Circuit Board No. 3 Pictorial (page 36). Refer to the Figure and note the following corrections:
 - a. Near the top of the circuit board are two 47 ohm resistors, both labeled "R314". The resistor on the left is R314 while the resistor on the right should be labeled "R315".
 - b. The polarity marking for diode D302 (1N270) has been omitted. Proper orientation of this diode is anode to the left and cathode (bar) to the right; the arrow of the diode symbol should point TOWARDS OA302.
 - c. The labeling of edge connector fingers "M" and "N" is interchanged. Finger "N" is the bottom finger and "M" is next to the bottom.

DO NOT START ASSEMBLY OF THE KIT OR ATTEMPT CONNECTION OF THE WIRED UNITS BEFORE THESE MANUAL CHANGES HAVE BEEN MADE.

Enclosures, July 25, 1975 ST-6 Manual Up-date:

Page 10	(7/75)	New Text
Page 11	(7/75)	Figure 1 Plug Connections for Printer, Scope, and AF Input
Page 12	(7/75)	Figure 2 Plug Connections for Key, FSK, and Remote
Page 12A	(7/75)	Figure 2A Preparation of Plugs
Page 13	(7/75)	New Text
Page 14	(7/75)	Figure 3 Interconnections from the ST-6 to Other Equipment
Page 16A	(7/75)	Figure 3A
Page 16B	(7/75)	Figure 3B
Page 18	(7/75)	New Text
Page 18A	(7/75)	Figure 3C Connector Orientation on Rear Panel
Page 27	(7/75)	Figure 5 ST-6 Circuit Boards 1 and 2
Page 28	(7/75)	Figure 6 ST-6 Circuit Boards 3, 4, and 6
Page 29	(7/75)	Figure 7 ST-6 Circuit Board 5
Page 30	(7/75)	Figure 8 ST-6 Wiring Diagram
Page 44	(7/75)	Revised Parts List
Page 45	(7/75)	Revised Parts List
Page 46	(7/75)	Revised Parts List

These pages have been inserted in the manual.

ST-6 OWNER: PLEASE NOTE THE FOLLOWING CHANGES IN YOUR OWNER'S MANUAL.

- (1) On page 22, section 3 under "Alignment of the ST-6," the third sentence states that you should check to see that the AC pilot light and space lamp glow. This should be changed to indicate that only the pilot light should glow at this point in the test procedure. Accordingly, delete the words "and the space lamp."
- (2) Refer to the large circuit diagram, drawing No. B915B, dated August 8, 1972. Note that the installation of terminal strip C on the front panel will require that the mounting tab (foot) attached to terminal lug seven (7) be cut off. Failure to cut off this mounting tab may result in an equipment failure, or a shock hazard if the tab were to ground out the meter switch.
- (3) Also in the drawing referred to above, note the two 0.001 uF disc capacitors (C8,C9) shown mounted between each of the scope outputs and ground (between pin one and ground and between pin three and ground). THESE CAPACITORS SHOULD BE DELETED.

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1. INTRODUCTION

The model ST-6 RTTY Demodulator is a high-performance, all solid-state demodulator for the reception of radio teleprinter RTTY signals. The ST-6 features separate pre-limiter bandpass filters and linear discriminators for reception of the standard 170 Hz and 850 Hz frequency shifts. The input limiter stage is capable of a dynamic range exceeding 80dB with negligible zero-level cross-over distortion. An automatic control holds the ST-6 in the mark condition when non-RTTY signals (such as voice, cw, or noise) are received. An anti-space control protects against continuous signals on the space frequency. The motor-control circuit switches the teleprinter motor on automatically when RTTY signals are detected, allowing full unattended autostart control of the teleprinter for monitoring net frequencies. The low-voltage supplies of the ST-6 are electronically regulated and a 175 volt, 60 ma loop supply is included in the demodulator. Normally supplied for use with 120VAC, 50-60 Hz power sources, the ST-6 can be modified for use with 240 vac power systems by rewiring connections to the power transformer. The complete demodulator is housed in a 3 3/4 x 17 x 12 cabinet and weighs 12 lbs (18 lbs shipping weight). Complete specifications are listed in the following section.

The manual contains complete operating instructions and a guide to servicing your ST-6. The construction procedure for ST-6 kits is also included. Whether your ST-6 comes in kit form or factory assembled, it will be worth your time to read this manual carefully before operating your demodulator.

2. SPECIFICATIONS

Input Frequency Range: 2000 - 3000 Hz

Input Impedance: 500 ohms, unbalanced

Input Bandpass Filter Bandwidth (-3dB): 1100 Hz (850 Hz shift)
260 Hz (170 Hz shift)

Input Limiter Stage Performance:

(Measured with a 2125 Hz signal on input of demodulator)

Limiting threshold: 1.0 mV peak-to-peak (limiter switch in "ON(FM)" pos.)
150 mV peak-to-peak (limiter switch in "OFF(AM)" pos.)

Maximum Signal Input: 10V Peak-to-peak (either limiter switch pos.)

Discriminator Performance:

Nominal Filter Center Frequencies:

850 Hz Shift: Mark - 2125 Hz \pm 5 Hz
Space - 2975 Hz \pm 5 Hz

170 Hz Shift: Mark - 2125 Hz \pm 3 Hz
Space - 2295 Hz \pm 3 Hz

Discriminator Filter Bandwidth (all filters - 3dB): 140 Hz (850 shift)
70 Hz (170 shift)

Minimum Detectable Frequency Shift: 850 Hz - 50 Hz
170 Hz - 10 Hz

Maximum Detectable Frequency Shift: 850 Hz - 1100 Hz
170 Hz - 350 Hz

Note: The linear discriminator in the ST-6 allows reception of shifts other than the standard 850 Hz or 170 Hz shifts, but the received audio tones must be centered in the bandpass of the discriminator selected; i.e., for shifts between 1100 Hz and 200 Hz, the tones should be centered on 2550 Hz; for shifts between 200 Hz and 10 Hz, the tones should be centered on 2210 Hz. Autoprint or autostart operation is restricted to shifts within the autostart bandwidth given below.

Autoprint Performance

Autostart Response Time: Slow - 3.5 sec
Fast - 1.5 sec

Motor Control Delay Time: 30 sec. nominal

Autostart Bandwidth: 850 Hz - 140 Hz
170 Hz - 70 Hz

Autoprint Operation

When no RTTY signals are recognized the autostart system places the demodulator in a standby mode with the printer motor and loop current defeated. Within 3.5 sec. (or 1.5 sec. in "Fast" mode) after recognition of a valid RTTY signal, the autostart system energizes both the motor and loop supply and allows the demodulator to key the loop. Within 3.5 sec. (or 1.5 sec.) after loss of signal, the system is placed in a "mark-hold" condition with loop supply and printer motor energized but with the loop keying stage defeated. If a signal is not recognized within a nominal 30 seconds, the printer motor is shut off and the loop current is interrupted to minimize standby power consumption. The autostart activation is sensed from the discriminator stage and is therefore frequency sensitive. As noted above, the autostart system is designed to work primarily with signals of standard frequency shifts (850 and 170 Hz) and should be defeated when print of non-standard shifts is desired.

Lowpass Filter Stage:

Cut-off Frequency: 27 Hz (60 wpm, 45 baud)
45 Hz (100 wpm, 75 baud)

The low-pass cut-off frequency is normally set at the factory for 75 baud to permit use of the ST-6 at speeds of 100 wpm.

Automatic Threshold Control:

This system allows copying of signals on a mark-only or space-only basis by providing automatic zero threshold correction. This circuitry functions best when the demodulator is used in the "FM" mode (limiter on) and offers outstanding performance with a relatively simple and economical circuit.

Outputs:

LOOP: Internal 175 volt, 60 ma loop supply; Printer selector magnets and transmitter contacts wired in standard series loop, connected to ST-6 with a $\frac{1}{4}$ " 2-circuit ("stereo") phone jack. When the "Auto" - "Standby" switch is in the "Standby" position, the keyer stage of the ST-6 is defeated and teleprinters can be used in "local-loop" configuration. Grounding the "remote" jack also places the demodulator in "Standby" condition for local loop operation.

FSK: A low-voltage keying source is provided at the FSK jack for driving FSK or AFSK keyer stages for transmission of RTTY signals. This feature is normally used in local-loop mode when transmitting (ST-6 in "Standby" mode), but the keying voltages are available at all times allowing the ST-6 to be used in repeater operations.

This output is EIA (RS-232) compatible and is used to drive the HAL RVD-1002 Visual Display system.

Nominal Voltages: Mark: -15 V (into a 1K load)
Space: +15 V (into a 1K load)

KEY: A telegraph key may be connected to the key jack to provide narrow-shift cw identification when transmitting. When used to key a FSK system, the amount of cw frequency shift is controlled by the "CW Shift" potentiometer.

SCOPE: A two-circuit, $\frac{1}{4}$ " jack is provided for connection to an external oscilloscope for use as a tuning indicator. Since a tuning meter is normally furnished with the ST-6, use of an oscilloscope is optional. Approximately 4 volts peak-to-peak (at the center frequency of each discriminator filter) is furnished to a 1 meg ohm oscilloscope input.

Printer:

A three-wire, U-ground AC receptacle is furnished on the rear panel to supply power to teleprinter motors. This output is controlled by the autostart circuitry. Total load should not exceed 10 amperes. Note: Fuse protection for this output is not provided in the ST-6 - each teleprinter should be fused.

Miscellaneous Data:

Fuse Protection:

AC Power Input - 0.5 amp. panel - mounted fuse holder

+ 12 V Supply - 0.25 amp, mounted on power supply circuit card

- 12 V Supply - 0.25 amp, mounted on power supply circuit card

Loop Supply - 0.1 amp time delay, mounted on power supply circuit card

Power Requirement:

120/240 VAC, 60 Hz (normally provided for 120 VAC unless otherwise specified - 240 V plug to be supplied by user)

Power Consumption: 7 watts maximum "Standby" configuration (loop off)
12 watts maximum "Receive" mode, loop on.

Voltage Tolerance: $\pm 10\%$

Mechanical:

Size: 3 3/4" high × 12" deep × 17" wide

Style: Table-top cabinet or standard 19" relay-rack mounting.

Weight: 18 lbs., shipping; 12 lbs. net.

Color: Light gray front and rear panels with dark gray wrinkle finish top, bottom, and side panels.

3. OPERATION

The ST-6 is one of the most elaborate RTTY terminal units offered to amateur radio operators. It incorporates many features which when properly understood and applied, can add much to your enjoyment of RTTY operation. The following discussion is a general guide to the use of these features and should be particularly helpful if you have not had experience with the advanced autostart circuitry first introduced in the TT/L and TT/L-II RTTY terminal units. As you gain familiarity with the ST-6, you will probably develop your own preferred techniques for operation.

Tuning a Radio Teleprinter Signal for Optimum Performance

Two different forms of tuning indicator are provided for in the HAL ST-6: the familiar crossed-ellipse oscilloscope display and a tuning meter. The meter is included in the ST-6; a jack on the rear panel is provided for connection to an external oscilloscope. Both techniques provide reliable indications and are considerably easier to use than describe!

When using the oscilloscope as a tuning indicator, a portion of the signal at the mark filter of the discriminator is coupled to one of the inputs of the scope (usually the horizontal input) and the signal at the space filter is coupled to the other scope input (vertical). When the receiver is properly tuned, the mark signal will produce a line or ellipse in the horizontal plane, and the space signal a line or ellipse in the vertical plane. If the received signal has the same shift as the TU discriminator, the two displays will be maximum amplitude at the same frequency on the receiver. The receiver is therefore tuned for a maximum in both lines. The discriminator in the ST-6 uses fairly broad bandwidth tuned circuits to achieve a linear response and therefore the scope patterns will be ellipses instead of lines. When tuning, adjust for maximum amplitude of the major axis of each ellipse and ignore the minor axis or width of the ellipse. The ellipses for the 170 Hz filters will be wider than those for 850 Hz shift.

Use of the tuning meter is straightforward, although it will require some time for RTTY enthusiasts familiar with the scope display to adapt to this. The signals from both the mark and space filters of the discriminator are detected and combined to produce a DC voltage that is positive for either tone (the "plus-plus" voltage). The voltage on the "plus-plus" line is therefore a direct indication of how close the received signal is to center frequency of each filter. This voltage will be a maximum when the received mark tone is correctly centered on the mark filter in the discriminator; the same applies to the space tone.

The discriminators of the ST-6 are preadjusted so that the maximum voltages from the space and mark filters are equal. Therefore, if a signal is tuned in so that both its mark and space signals are centered on the ST-6 discriminator filters, the voltage on the "plus-plus" line will be a maximum for either tone, and in fact, will not change as the signal goes from mark to space and back. This "plus-plus" voltage is indicated on the tuning meter.

Correct tuning on the meter is therefore indicated by maximum deflection that does not vary as the incoming signal switches back and forth between mark and space.

Now consider what the meter indication will be if the signal is not tuned correctly; if tuning is set so that more output occurs from one filter than the other, the tuning meter may not read maximum deflection and will definitely flicker when the signal goes from mark to space. If no RTTY signal is present, the tuning meter will not read as high and will flicker widely on the incoming noise (for the present discussion, any interference such as CW or SSB is also considered to be noise).

If the received signal is transmitted with a frequency shift somewhat different from the standard 850 or 170 Hz shifts provided for in the ST-6, it will be impossible to adjust the receiver for maximum deflection of the meter with no flicker, since it is impossible to get both tones centered on both filters at the same time. However, the ST-6 will very reliably copy shifts considerably narrower than the design center by straddle-tuning the signal. This is the primary reason for use of the linear discriminator.

When straddle-tuning a signal, adjust receiver tuning for minimum flicker of the tuning meter. This receiver setting will not produce maximum deflection, but the demodulator will still perform properly (except for the autostart circuit, as will be discussed later). The tuning meter driver circuit is adjusted so that a RTTY signal with proper shift and correctly tuned will produce a meter deflection of 0.7 ma in the 850 Hz shift mode and 0.6 or higher in the 170 Hz mode.

With either type of indicator it is best to defeat the autostart circuitry when tuning by placing the "AUTO - AUTO OFF" switch in the "AUTO OFF" position. Although the ST-6 will reliably print very narrow shifts, the autostart imposes rather tight tolerances on the shift to minimize unwanted turn-on's. It is also best to tune in stations with the limiter set to "ON(FM)" and then go to limiterless operation "OFF(AM)" if necessary to copy through interference.

The ST-6 Autostart System

The autostart system in the ST-6 is considerably more complex than those circuits normally added to terminal units to simply turn the printer motor on and off. Two independent functions are controlled in the ST-6 - the keyer stage operation and the power to the printer motor. Control of the keyer stage provides a fairly rapid means of placing the printer in mark-hold condition while keeping the motor on for a predetermined length of time.

This feature is particularly convenient when in QSO, since the machine prints little garble between the end of one station's transmission and the beginning of another's. Properly adjusted, the autostart is even immune to the station's CW identification (if narrow-shift CW ID is used).

If a RTTY signal is not received within 25 to 50 seconds (the exact time may vary between units because of electrolytic capacitor tolerances) after a station ceases transmitting, the printer motor is shut off. The keyer and

printer motor are re-activated automatically whenever a signal is received (within 3-4 seconds in "SLOW" mode and approximately 1 second in "FAST" mode).

The autostart circuit is triggered from the same "plus-plus" line used to drive the tuning meter. A threshold level adjustment (the trim-pot on circuit board 4) presets the voltage required to trigger the autostart. Since the amplitude of the "plus-plus" voltage is proportional to frequency, this adjustment also sets the shift-frequency tolerance of the autostart trigger point. If the trigger threshold is adjusted close to the maximum voltage available from the plus-plus line, the autostart will trigger only on strong signals with exactly 850 Hz shift. If it is adjusted too far the other way, the autostart will never deactivate.

The autostart trigger threshold is normally adjusted to trigger on any signal that gives a tuning meter indication of 0.6 ma or higher, but you may wish to experiment with this adjustment to determine the trigger level you prefer. Set at the 0.6 ma level, the autostart will respond to signals within approximately ± 100 Hz of 850 Hz shift and ± 45 Hz of 170 Hz. This tolerance becomes considerably tighter for weak signals.

An additional feature of the motor control circuit is that when power is removed from the printer motor, the loop current of the ST-6 is removed by shorting the base of the keyer transistor to ground. This reduces the power consumption and heat generated during stand-by periods.

There are four toggle switches and two pilot lamps which control and monitor the operation of the ST-6 autostart circuits:

SLOW - FAST: This switch controls the turn-on time of the autostart system. In the "SLOW" position a RTTY signal must be present for approximately 3 to 5 seconds (5 or 6 characters) before the autostart will actuate. This delay provides fairly good protection against false turn-on's. The "FAST" position allows the TU to activate in less than a second, particularly convenient for fast-break operation. The motor relay and therefore the printer motor are held on whenever the switch is in the "FAST" position.

AUTO - AUTO OFF: This switch defeats the autostart circuitry for tuning or for full manual operation.

AUTO - STANDBY: In the "STANDBY" position, the ST-6 is locked in a mark-hold condition with the printer motor on. Received signals will not be printed but the tuning indicators will still function. This control is quite convenient for use when transmitting. It is paralleled by the remote jack on the rear panel so that it may be connected to station transmit-receive control circuitry.

AUTO - MOTOR: In the "MOTOR" position, the printer motor control feature is locked out and the printer motor is held on.

RECEIVE: This pilot lamp will light whenever the autostart has activated the TU for reception of RTTY signals.

STBY: This pilot lamp lights whenever the autostart is not active and the printer is being held in the mark-hold condition or when the motor has been turned off. Note: Both the "RECEIVE" and "STBY" lamps will be lit whenever the "AUTO" - "STAND-BY" switch is in "STAND-BY" position or when the remote jack is shorted. This provides a positive indication that the TU is in the standby mode and serves as a warning that the TU will not receive signals.

As discussed previously it is usually easiest to tune the receiver with the autostart defeated until you have become familiar with autostart operation. The time delay generated by the autostart, particularly in the "SLOW" mode, can be particularly disconcerting if you expect to get print-out immediately upon achieving correct tuning. Autostart operation is most useful for monitoring net frequencies and during QSO's, particularly in round-table discussions.

The ST-6 Anti-space Circuit

The ST-6 includes a circuit that prevents the printer from "running open" if a continuous space tone is received. The circuit senses the length of time that a space signal is present at the output of the slicer stage. If it exceeds the maximum possible time permitted by the Baudot (RTTY) code (132 ms for a blank key), the keyer stage is placed in mark-hold condition, as in autostart operation. Also, the output of the anti-space circuit is coupled to the autostart circuit so that the motor is shut-off if the space condition persists. The anti-space mark-hold feature is always active in the ST-6.

Other Controls

The functions of the remaining controls on the ST-6 are as follows:

SHIFT (170 - 850): Either of the two standard RTTY shifts is selected with this switch. It connects the correct input filter, limiter, discriminator, and low-pass filter section for the shift to be demodulated. It also switches the plus-plus line from one discriminator to the other, and the AK-1 AFSK oscillator, if used. On demodulators with the 3-Shift option, a third switch position selects 425 Hz shift.

LIMITER (OFF(AM) - ON(FM)): The input amplifier can be switched from limiting operation to a linear amplification mode with this switch to allow limiterless reception, sometimes useful in copying weak signals through interference. The switch controls the limiter stages for both 170 and 850 Hz shifts. The autostart circuitry is automatically defeated when the switch is in the "OFF(AM)" position.

NORMAL - REVERSE: This switch reverses the input to the slicer stage for copying signals with reversed shift. For reception of HF FSK signals in the "NORMAL" position, the receiver should be used in the lower sideband mode. VHF AFSK signals should copy in the "NORMAL" position if the convention of low-tone mark is followed.

METER (TUNING - LOOP (100 ma)): In the "TUNING" position, the meter functions as a tuning meter, as discussed previously. In the "LOOP" scale of 0-100 ma, it monitors the loop current.

MARK - SPACE: These two neon pilot lamps indicate the condition of the loop circuit. They normally flash when receiving RTTY signals. They are particularly good for impressing visitors to the shack, although some people have used them for tuning indicators.

ON - OFF: This switch controls all power supplies, including the loop supply. The printer motor power is not directly controlled by this switch but cannot be activated with the ST-6 off, since the motor relay controls the printer motor.

0.5 AMP: This is the AC fuse for all power supplies in the ST-6. It does not protect the printer motor since the motors are usually fused in the printer housing itself.

CW SHIFT: When using the Mainline FSK keyer system, this potentiometer adjusts the shift for CW identification.

External Connections

The following rear-panel connections are provided on the ST-6:

AF IN: The audio output from the station receiver should be connected to this jack. Use the receiver's 500 ohm audio output if at all possible. A low impedance output will work, but will reduce the potential limiting by some 30 dB. Voice-coil to 500 ohm line transformers are available at reasonable cost and are a worthwhile investment. The receiver volume need not set very high, particularly if the 500 ohm output is used. See Figure 1 for connection details.

SCOPE: An external oscilloscope can be used as a tuning indicator by connecting the vertical and horizontal scope inputs to the three pin connector on the rear panel of the ST-6. Usually, the Mark signal (pin 1) is connected to the horizontal input and the Space signal (pin 3) is connected to the vertical input of the scope. Use a length of two conductor shielded cable to make this connection with the shield connected to pin 2 of the scope connector and to the ground of the scope. Preparation of the connector pins is shown in Figures 1 and 2A. Be sure that the pins are installed in the proper location in the connector shell.

REMOTE: An external switch or set of relay contacts can be connected between pins 5 (ground) and 6 of the Control connector to provide remote standby control. The ST-6 will demodulate signals and drive the printer when there is an open circuit between pins 5 and 6. When the pins are shorted together, the ST-6 output is held in mark-hold condition. This feature allows automatic control of the ST-6 by the transmit-receive circuitry of the station. Preparation of the connector pins is shown in Figures 2 and 2A.

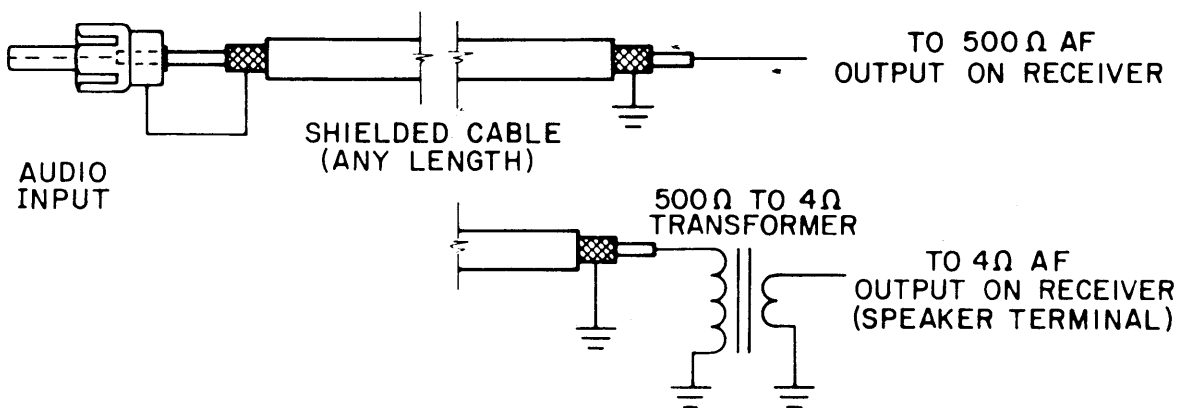
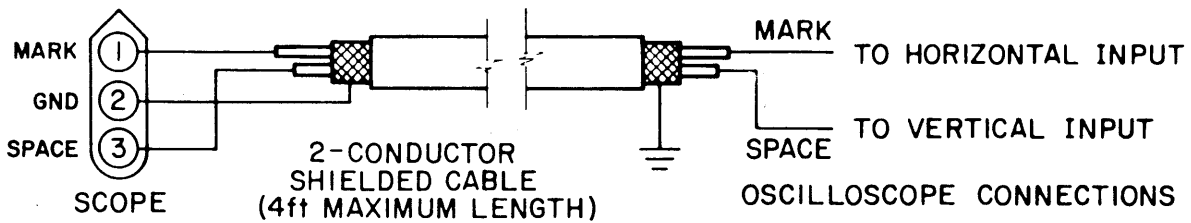
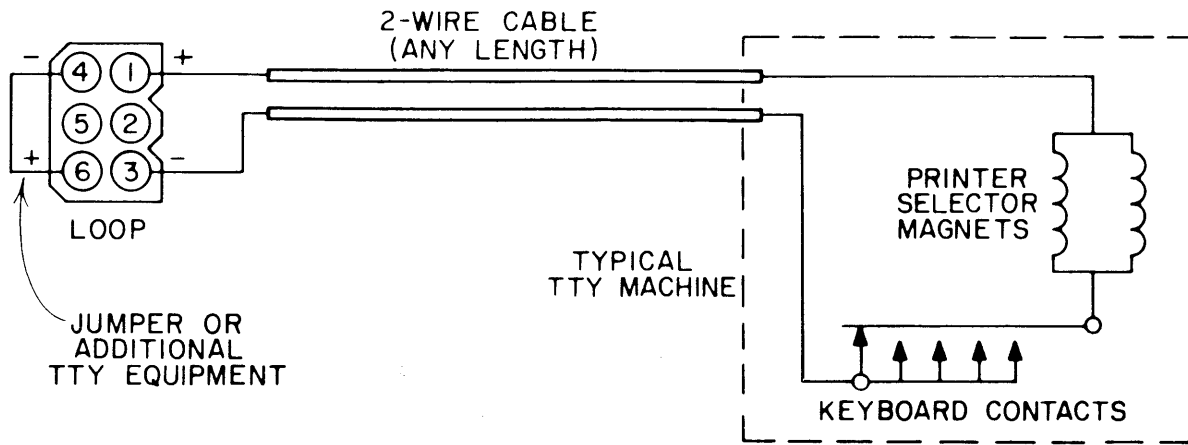


Figure 1 Plug Connections for Printer, Scope, and AF Input

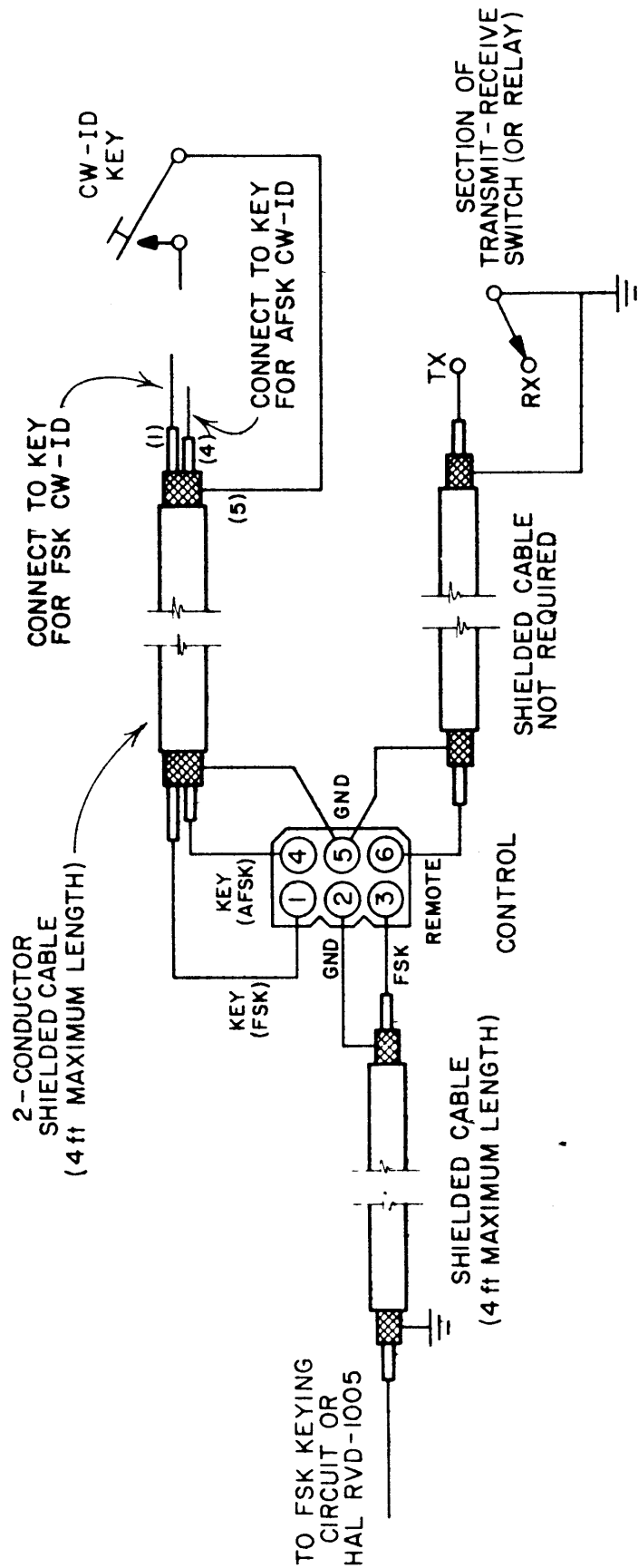


Figure 2 Plug Connections for Key, FSK, and Remote

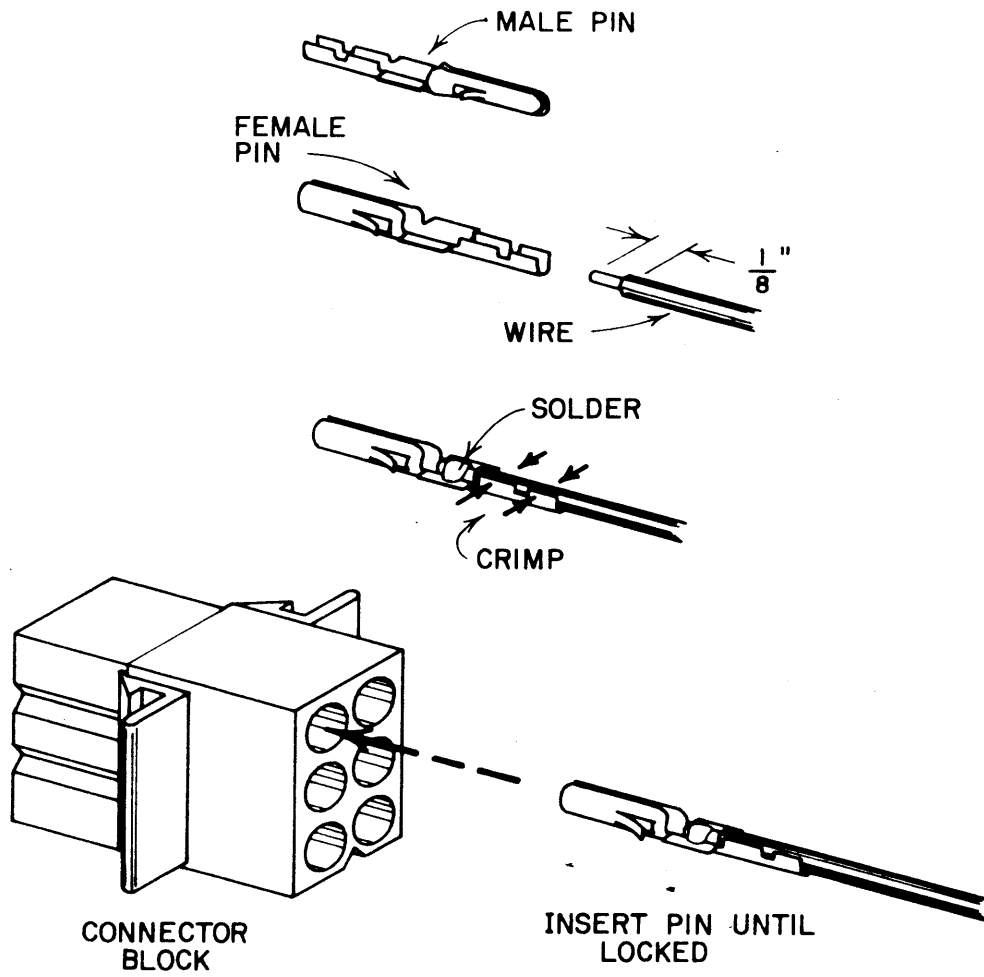


Figure 2a Preparation of Plugs

KEY: A key can be connected to the Control jack for CW identification with either narrow-shift AFSK (with the AK-1 or XTK-100) or with a Mainline FSK system. The key should be normally open. For AFSK cw identification, connect the key between pins 4 and 5 (ground). For FSK cw identification, connect the key between pins 1 and 2 (ground). See Figure 2 for connection details and Figure 2A for preparation of the connector pins.

FSK: The keying voltages provided at this pin on the Control connector are fully compatible with the Mainline FSK keying system. For a full discussion of a FSK system, see Hoff's article in May, 1965 QST, page 16. The FSK output can also be connected to the Voltage (or EIA) Input on the HAL RVD-1005. See the RVD-1005 manual and Figures 2, 2A, and 3 for further details.

LOOP: Connect the RTTY printer and other RTTY equipment to this connector. Normally, the printer and keyboard of a machine are series connected at the machine and the two wires then connected to the plug. If only one piece of equipment is to be connected to the ST-6, connect it to pins 1 and 3 of the loop connector and place a jumper wire between pins 4 and 6. An additional machine can be connected to pins 4 and 6 in place of the jumper. Cables from the printer and keyboard should be wired as shown in Figure 1. No portion of the loop should be connected to ground.

Preparation of the various connectors is shown in Figures 1, 2, and 2A. Typical interconnections between the ST-6 and other RTTY equipment are shown in Figure 3.

NOTE: The pins cannot be easily removed from the plug shells after they have been inserted. Refer to Figures 3C (page 18A) and 8 (page 8) as well as to the markings on the exterior of the rear panel to make sure that connection is made to the proper pins BEFORE inserting them into the plug.

MOTOR: If the power cord of the printer is plugged into this connector, the ST-6 autostart circuitry will automatically turn the printer motor on and off. Note that a three-conductor grounding socket is provided. It is strongly recommended that the printer motor be equipped with a grounding power cord and that the frame of the printer be firmly attached to a good electrical ground.

AC POWER CORD: A standard three-wire grounding power cord is furnished with the ST-6 for connection to 115 / 120 V, 60 Hz power mains. ALWAYS OPERATE THE ST-6 WITH AN ADEQUATE GROUND. FAILURE TO GROUND THE UNIT OR DEFEAT OF THE POWER CORD GROUND VOIDS THE WARRANTY. When operating the ST-6 from a 230 V power line, be sure that the transformer primaries are properly connected and that the proper plug is installed on the power cord. Again, the ST-6 must be properly grounded.

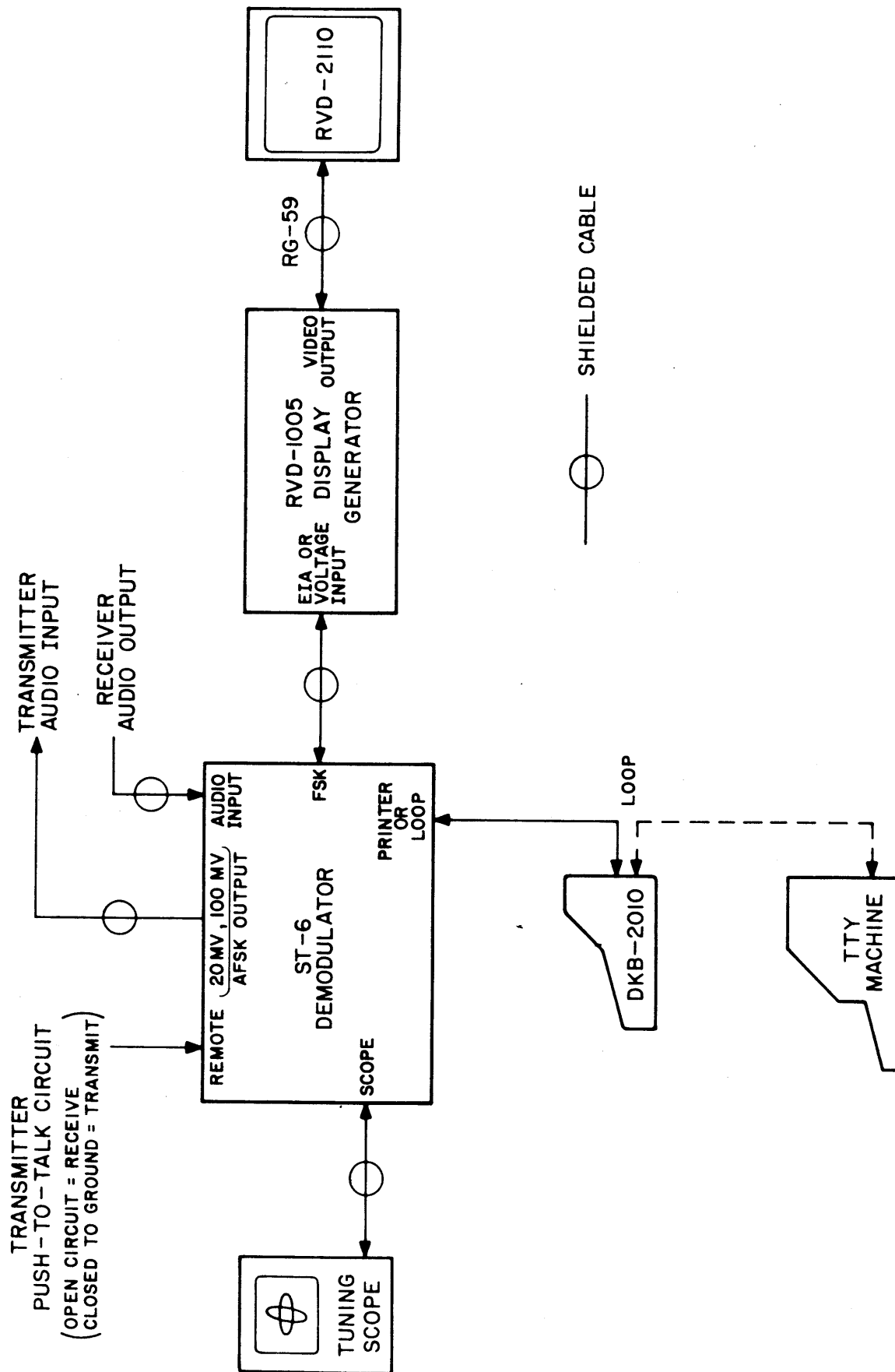


Figure 3 Interconnections between the ST-6 and Other Equipment

4. ST-6 KIT CONSTRUCTION

The HAL Communications Corp. ST-6 parts kit furnishes the experienced RTTY enthusiast with quality parts at a reasonable price for the construction of the ST-6 RTTY Terminal Unit described by Hoff in September and October, 1970, RTTY Journal, and January and February, 1971, HAM Radio. To provide for all features of the terminal unit, a set of seven printed circuit boards and associated components are furnished. This is not a kit in the usual sense; step-by-step instructions are not furnished. It is assumed that the builder has experience in electronic construction and can build from schematics and pictorial layouts with a limited amount of suggestions. This is NOT a kit for beginners to undertake! A few helpful hints regarding circuit board construction in particular are included, but a number of details are left to the inventive mind of the builder.

The parts for the ST-6 have been packaged with all resistors in one sack, all capacitors in another, etc. Upon receipt of the parts kit, the builder should unpack ALL components and separate them according to the individual parts lists for each circuit board. Notify HAL Communications Corp. immediately of any shortages so that we may promptly rectify the problem. All components are covered by the standard HAL Communications Corp. one-year warranty. If a failure occurs, please write giving full details. DO NOT ship any item back without prior notice to HAL Communications Corp.

The following pages of construction techniques are a collection of hints for the construction of the circuit boards and placement of parts and boards in the cabinetry. Please read the entire manual before starting construction.

Construction of Circuit Boards

The pictorial layouts show the placement of the components on the boards. The Molex Soldercon terminals for the integrated circuits should be inserted and soldered to the board first. The Soldercons are supplied in 7 pin strips, two per integrated circuit. DO NOT remove the individual pins before soldering the strip in place. Insert all Soldercon strips at the appropriate positions and solder them in place. Use great care in soldering to prevent solder from flowing inside the pins and from bridging across the closely spaced pads on the circuit board.

After all the Soldercons for a given board have been soldered in place, the "carrier" strips are removed from between the pins by gripping the carrier strip firmly with longnose pliers and bending gently in a downward direction away from the pins. There is a pre-formed indentation along the carrier at each pin so that the carrier will snap off without too much force. Be careful not to bend any of the terminals when removing the carriers. The integrated circuits can now be inserted in the Soldercon terminals - be sure to position the "U"-shaped indentation on the top of the IC at the proper end as indicated in the pictorials.

The resistors should be inserted next. Unless otherwise noted all resistors are inserted vertically. When installing vertically mounted components, place

the component body as shown in the pictorial. Solder the resistors as they are installed. The capacitors should be installed next. Be sure to observe polarities on electrolytics. It is good construction practice to orient components so that their labels can be read easily after the board is constructed.

Semiconductors (other than the ICs) can now be mounted; avoid overheating the germanium diodes. All diodes are mounted vertically. Make sure that transistor orientation agrees with the pictorial drawing, and observe diode polarities. Larger components, such as toroids, trim-pots, and the electrolytics on boards 4 and 5 are mounted last.

It is much easier to adjust the tuned circuits before they are mounted on the circuit boards. A good procedure is to construct all other portions of the circuit boards and then tune all ten toroids as a final step. Tuning procedures are discussed later in the manual. A few specific hints for the construction of each board are listed below.

Circuit Board No. 1 - Filter/Limiter (Figures 5, 9 and 10)

The layout shown in Figure 9 applies to the 850 Hz shift filter-limiter board; that shown in Figure 10 applies to the 170 Hz shift board. Five extra pads are provided on the circuit board for use in trimming the tuning capacitors to the correct values (C102A, C104A, C106A, C107A, C108A on board 1-850 and C152A, C154A, C156A, C157A, C158A on board 1-170).

The 22 mHy inductors required for the 170 Hz shift filter are derived by parallel-connecting the two windings of the toroids in parallel-aiding ("loose-ends" tied together and "tails," or sleeved ends, together). The 88 mHy toroids for 850 Hz shift are derived by series-aiding connection of the toroids.

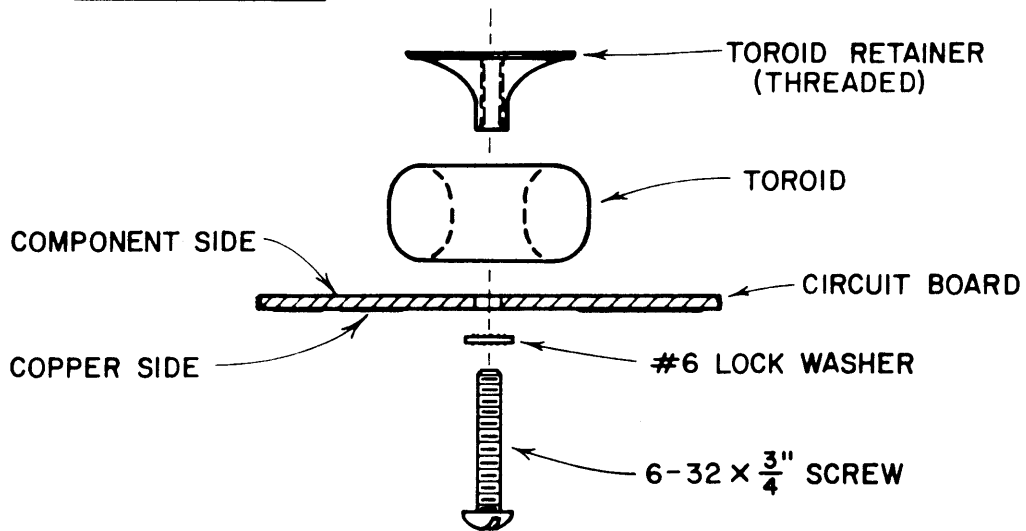
The toroids are mounted to the board with the #6 hardware and large washers supplied. Assemble the hardware as follows (from top-to-bottom): screw-head, #6 flatwasher, nylon washer, toroid, circuit board, #6 lockwasher, #6-32 nut. The complete assembly should have the toroid and screw-head on the component side of the board and the nut and lockwasher on the copper side of the board.

An extra ground pad connection is provided for each toroid for greater convenience in connecting the toroids to the boards, particularly when the parallel connection is used. When the series connection is used, a spare, isolated pad (marked "CT") is provided for each toroid center tap.

Circuit Board No. 2 - Discriminator/Detector/Active Lowpass Filter (Figures 5, 11 and 12)

The board pictorial shown in Figure 11 is used for 850 Hz shift and that shown in Figure 12 is used for 170 Hz shift. Extra pads are provided to aid in tuning the toroids.

SINGLE TOROID



STACKED TOROIDS

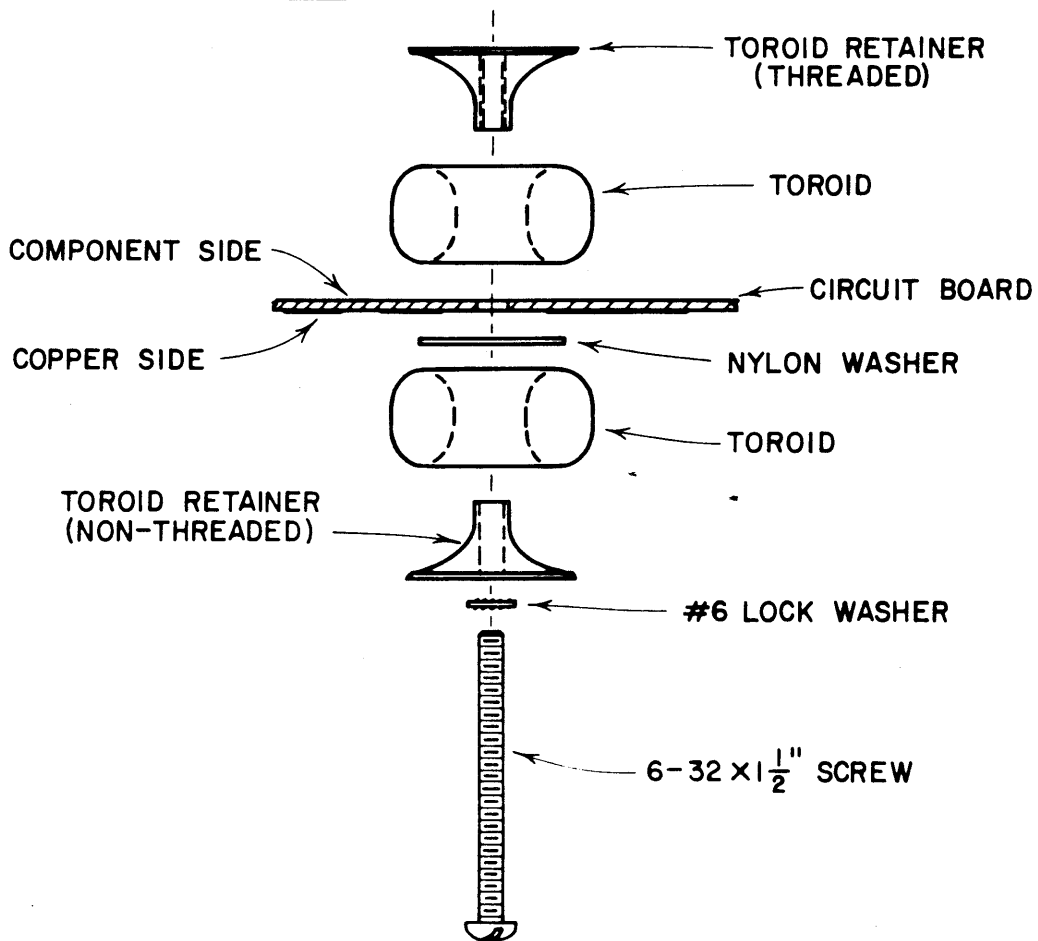
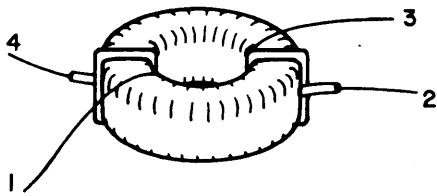
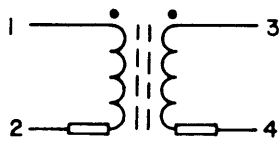
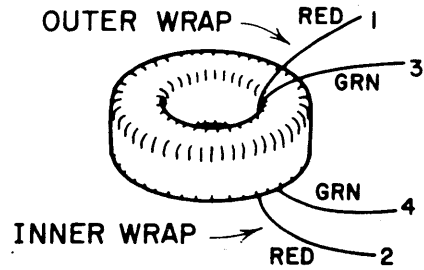
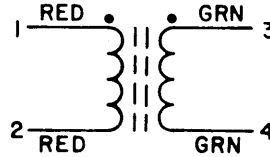


Figure 3a Toroid Mounting

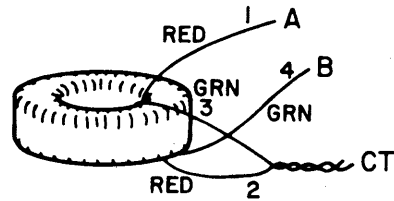
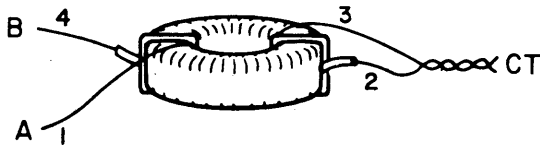
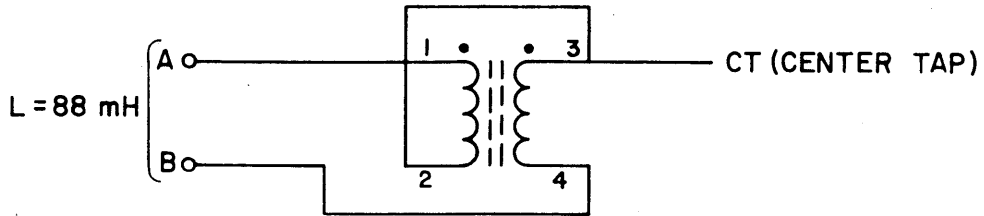
STANDARD



MULTICOLOR



SERIES CONNECTION, 88 mH



PARALLEL CONNECTION, 22 mH

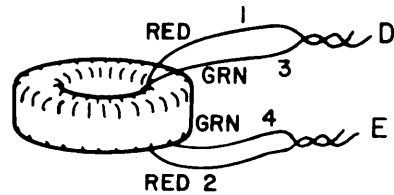
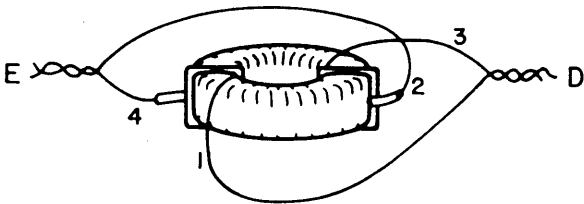
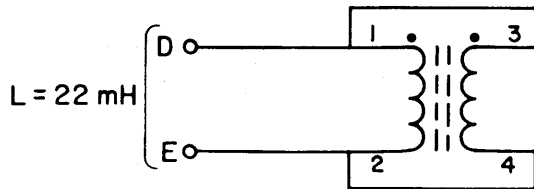


Figure 3b Toroid Wiring

Mount one toroid on each side of the board, assemble the parts in the following order: screw-head, #6 flatwasher, nylon washer, toroid, circuit board, nylon washer, second toroid, nylon washer, #6 flat-washer, #6-32 nut. The screw-head should be on the component side of the board and the nut on the copper side. It does not matter which toroid is used for L201 or L202. For both 170 and 850 Hz shift the toroids are connected in series-aiding. The board pictorial gives the value(s) of capacitors C206 and C256 for 60 and 100 wpm. Use the 100 wpm value if you intend to copy any speeds over 60 wpm.

Circuit Board No. 3 - Active Lowpass Filter/Slicer/Keyer (Figures 6 and 13)

Construction of circuit board No. 3 is quite straightforward. Observe the proper orientation of the 2N5655 transistor as indicated on the pictorial diagram. The electrolytic capacitors are mounted vertically (observe polarity). The pictorial shows the values of R301 and R302 required for 60 and 100 wpm. As on board No. 2, use the 100 wpm values if operation at speeds greater than 60 wpm is intended.

Circuit Board No. 4 - Autostart/Anti-space (Figures 6 and 14)

Install the IC's and resistors first, then the capacitors and remaining semi-conductors. Mount the 500 ohm, 5 watt power resistor horizontally, spacing it up off the board $\frac{1}{2}$ to $\frac{3}{8}$ " to allow for proper heat circulation. The 350 ufd and 150 ufd electrolytic capacitors are mounted horizontally; all other capacitors are mounted vertically. Note that a $\frac{3}{8}$ " wire is mounted near the upper left corner of board No. 4. This is Test Point No. 4 for use in alignment of the autostart circuit.

Circuit Board 5 - Power Supplies (Figures 7 and 15)

The normal order of component insertion should be modified for this board: put the power silicon diodes on the board first. The power diodes should be mounted vertically. Next, mount the fuse clips on the component side of the board with the 4-40 hardware supplied. The correct order of assembly is: screw head, clip, #4 lockwasher, circuit board, #4 lockwasher, #4-40 nut. Be careful that the lockwashers do not short to adjacent paths. The resistors should now be mounted vertically. Be sure to observe proper placement of the resistor body. The two transistors and remaining diodes can now be mounted. Carefully observe diode polarities and transistor orientation. Next mount the ceramic capacitors and, as a final step, mount the electrolytic capacitors, observing proper polarities. The 100 ufd 250 V electrolytic is mounted horizontally - all other electrolytic capacitors are mounted vertically.

Circuit Board #6 - Meter & Lamp Driver Circuit Board (Figures 6 and 16)

This board is extremely simple. Just build it according to the pictorial. An angle bracket and 4-40 mounting hardware are furnished to mount the board. Bolt the bracket to the component side of the board before mounting the 150-ohm lamp-dropping resistors. The meter and both pilot lamps are connected directly to this board.

Cabinet Wiring (Figures 3A and 8)

Included in the kit are a number of components that mount in the cabinet rather than on the boards (e.g., switches, connectors, transformers, etc.). Interconnection of the edge connectors and these components is shown in the wiring diagram and on the schematics. The functions and positions of the various switches are also indicated on the diagrams.

The shift selector switch (S8) supplied with the ST-6 kit is a 6PDT rotary switch. When the 425 Hz discriminator accessory kit is installed, S8 is replaced with a 6P3T switch furnished as part of the accessory kit. If you plan to install the 425 Hz discriminator during construction of the ST-6, consult the accessory kit manual and install the 6P3T switch rather than the switch furnished with the standard ST-6 kit.

The multiple contact connectors furnished with the kit for the Loop, Control, and Scope connections should be installed on the rear panel as shown in Figure 3A on page 18A. Be sure to use the "enclosed" shell (male) 6 pin connector for the Loop connections and the "open" shell (female) for the 6 pin Control connector and the 3 pin Scope connector. Also, observe the proper orientation of each connector as shown in Figure 3A. The three-lug terminal strips mount adjacent to each of these connectors, two strips for the 6 pin connectors and one strip for the 3 pin connector. When fastening all terminal strips to the panel, place a No. 6 lockwasher between the mounting "foot" of the strip and the panel.

Before attaching any other wires to the three lug strips, install and solder 0.001 ufd disc capacitors between the center lug (ground) and each end lug of the strips. Use the bottom holes for all capacitors.

Refer to Figure 2A (page 12A) and attach 2 $\frac{1}{4}$ " pieces of hook-up wire to 6 female connector pins and 9 male pins. After the wires are connected to the pins, insert the 6 female pins into the rear of the Loop connector and 6 of the male pins into the rear of the Control connector. Similarly, insert the three remaining male pins into the rear of the Scope connector. After the pins are inserted into the proper connector shells, attach the other ends of the 2 $\frac{1}{4}$ " wires to the 3 lug terminal strips as shown in Figure 8 (7/75). Wire the rest of the rear panel and cabinet as shown in Figure 8.

Mount the 2750 ohm, 20 watt power resistor on the 6 lug terminal strip as shown in Figure 8, being careful to dress it away from the relay and Loop connector.

The tuning meter may be switched to monitor loop current. Resistors are chosen for a full scale sensitivity of 100 ma. The autostart relay may be mounted wherever convenient, lead length should not be critical. A female 110 volt AC connector is supplied for the printer motor connection. Locate it on the rear panel of the enclosure.

Three neon lamp assemblies are furnished with the parts kit. One neon is used as an AC power indicator and should be placed in series with a 68K, $\frac{1}{2}$ watt resistor (R8) across the power transformer primary. The other two neon assemblies can be used to indicate MARK and SPACE conditions and should be connected with 82 K, $\frac{1}{2}$ watt series resistors (R1 and R7) as shown in the schematics.

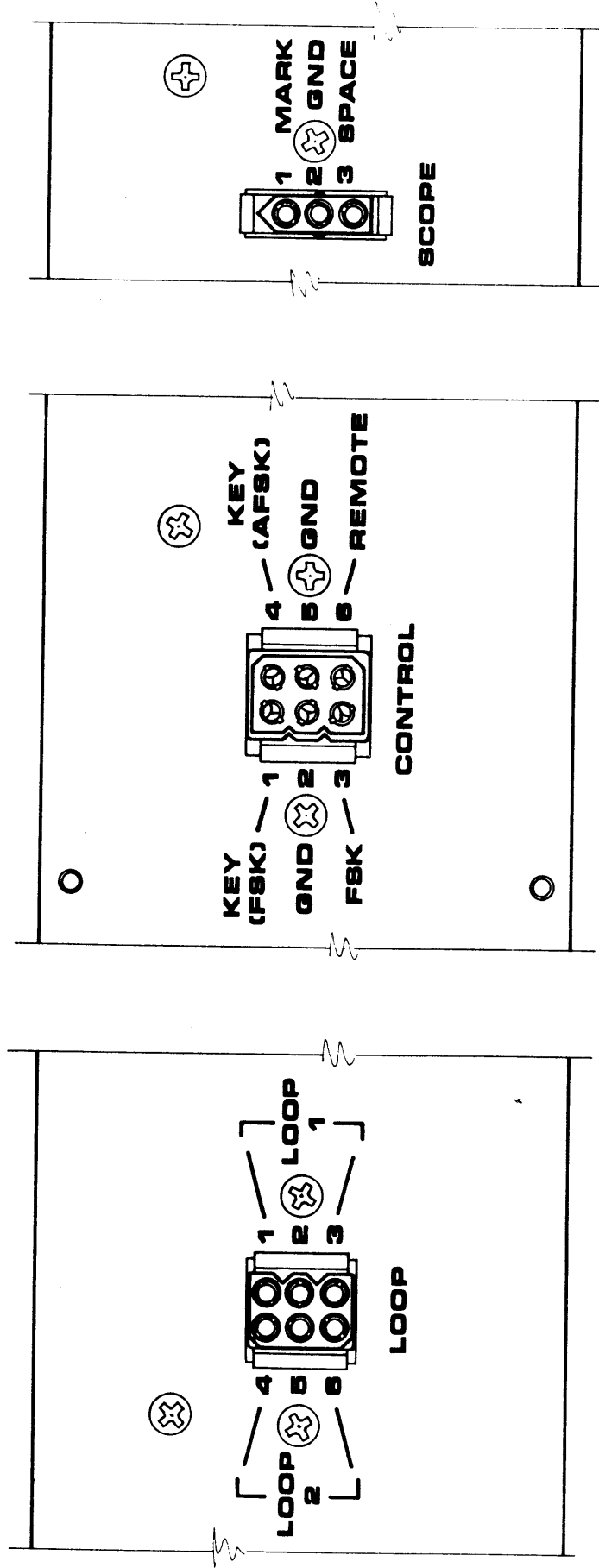


Figure 3c Connector Orientation on Rear Panel

The transformer can be mounted wherever convenient. Tie strips are provided for connecting the transformer leads to the wires which run to the edge connector for board #5, and to the AC line.

A final word concerning arrangement of the boards and critical lead lengths: The board placement implied by the wiring diagram is by no means the only or necessarily the optimum arrangement. The circuitry on the boards follows a more-or-less logical progression from board #1 to board #5. However the use of two #1 boards and two #2 boards for both shifts complicate the matter somewhat.

The most critical of the lead lengths is that between the limiter on-off switch (S1) and the circuit boards. It should be reasonably short. It is a good idea to shield the audio input lead to the shift switch from the input connector. Leads to S2 (Normal-Reverse Switch) should also be reasonably short. Therefore, the position of boards #1 and #3 within the cabinet will determine the locations of S1 and S2 on the front panel. Plan the panel layout before determining the positions of the boards.

For the shortest lead lengths to S1 and S2, it is best that boards 1 and 3 be positioned with the edge connector towards the front panel. Orientation of the other boards is optional, but it is easiest to wire the edge connectors if they are all lined up (particularly for power supply connections and connections to the many switches for the autostart board #4). If the circuit cards are lined up in a row, the power supply board (#5) should be at one end to allow easy connection to the power transformer.

Figure 8, the pictorial wiring diagram, shows the board arrangement used for factory-assembled ST-6's. If you will be building your demodulator in the special HAL ST-6 cabinet, it will be easiest to simply follow this diagram.

Remember when planning the board layout to leave room for the 425 Hz discriminator board and the AK-1 AFSK oscillator board if you will be adding them now or at a later time.

The circuit boards are arranged in the HAL cabinet so that the components on boards 1-850, 1-170, 2-850, and 2-170 (as well as the AK-1, when used) face to the left of the cabinet when viewed from the front. Conversely, components of boards 3, 4, and 5 face to the right. To minimize confusion, pins of the cards facing left are numbered from 1 to 12 (bottom to top), and cards facing right are lettered from A to N (bottom to top). The layout drawings are labeled to assist in servicing and signal tracing. This is a change from nomenclature used in previous editions of this manual and applies to all wired ST-6 Demodulators with serial numbers of 168 and higher, as well as all kits provided with this manual. This modification was made to allow expansion of the ST-6 (addition of the third discriminator board to copy 425 Hz shift) and should be followed when constructing the kit to assure compatibility with future factory modifications to the ST-6. Follow the pin labeling shown on the layout sheets for cards 3, 4, and 5 and ignore the numbers printed on these cards.

5. ALIGNMENT AND TESTING

Tuning the Toroids

There are ten toroidal tuned circuits in the full ST-6 -- three in each input bandpass filter and two in each discriminator. The accuracy with which these circuits are tuned will greatly affect the overall performance of the ST-6. It is therefore important to perform the adjustments very carefully.

There are many techniques that can be used to tune the toroids. Most are described by Hoff in "Checking RTTY Shifts" (QST, May, 1966, p. 35). This article is must reading and should be included in the technical library of all amateurs interested in RTTY operation. Valuable information concerning the input filters is found in the two-part series "High-Performance RTTY Filters" in August and September, 1966, QST also by Hoff.

The procedure described below is used in alignment of all HAL-constructed ST-6's. You may wish to modify it somewhat to conform to available test equipment. As shown in Figure 4 below, the test set-up at HAL used an audio oscillator, oscilloscope, AC VTVM and a frequency counter. The 100K resistor isolates the tuned circuit from the low output impedance of the audio oscillator.

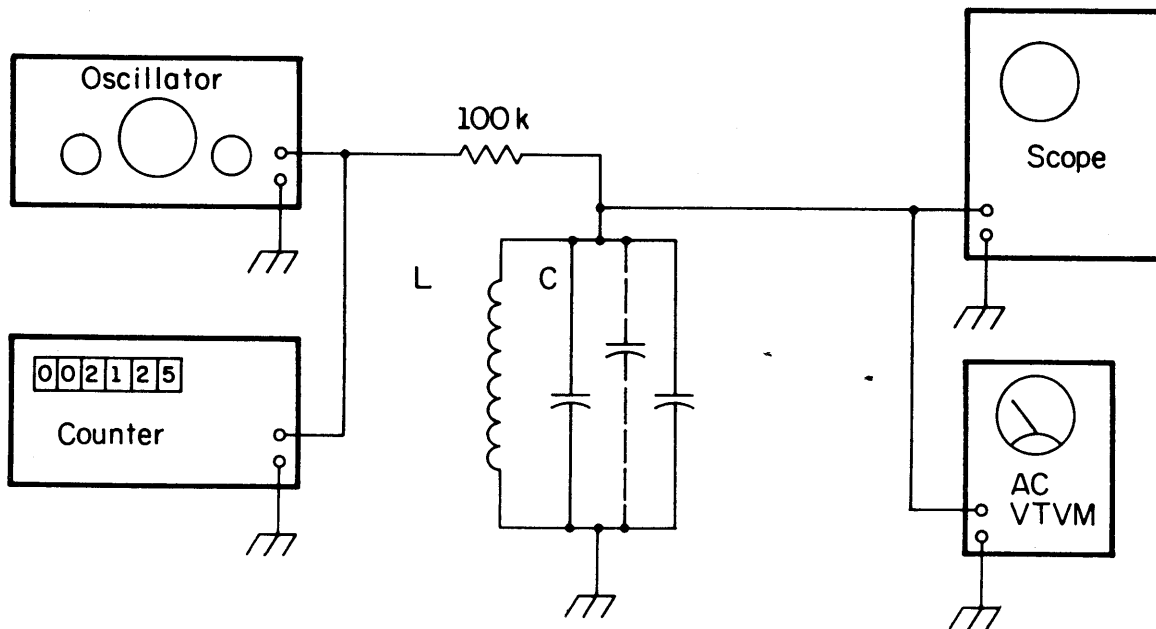


Figure 4
Toroid Alignment Techniques

As mentioned before, the adjustment procedure is much easier if performed before the toroids and tuning capacitors are installed on the boards. To adjust a tuned circuit; connect the toroid and capacitors as shown in the drawing. Set the audio oscillator to the desired resonating frequency as indicated by the counter. Adjust the oscillator amplitude until a usable reading is obtained on the VTVM and oscilloscope. Using the meter and scope as peak detectors, vary the audio oscillator frequency until the voltage across the circuit is at a maximum. Then note the counter reading.

If the frequency measured is lower than desired decrease the inductance by removing turns from the toroid; if the frequency is too high, add additional capacitance in parallel with the toroid. Each turn removed will increase the resonant frequency by approximately 3 Hz for a 2125 or 2295 Hz center frequency and 5 Hz at 2975 Hz. Conversely, each 100 pf of capacitance added will lower the resonant frequency by approximately 2 Hz at 2125 and 5 Hz at 2975 Hz. Note that these are approximate guidelines. Tune in small steps, particularly if removing turns!

The input bandpass filters are the easiest to tune and are the least critical. Note that in the layout pictorial diagram three frequencies are indicated, one for each toroid. These frequencies are the tuning frequencies associated with each inductor (f1 for L101, etc.). If the filters are tuned after all components are mounted, each inductor should be tuned separately with the others shorted. The same procedure can be used before mounting the components by remembering to add the coupling capacitors to the tuned circuit. So, in tuning L101 to 2400 Hz, use a toroid in the series 88 mHy connection paralleled by a 0.015 (C101), 0.018 (C102), and another 0.015 (C107). Similarly, L102 is tuned with C103, C104, C107, and C108 in parallel; L103 with C105, C106, and C108.

Tuning of these circuits is not overly critical and a tolerance of 20 Hz is reasonable. In general, most of the tuned circuits will be high in frequency initially requiring addition of parallel trimming capacitors. When parallel-connecting the toroids to get 22 mHy for the 170 Hz filter, be sure to parallel the windings in the proper phase (sleeved ends together, loose ends together). When adding capacitors for tuning, use mica, polystyrene, mylar, or paper capacitors (in that order of preference). DO NOT use ceramic, electrolytic, oil, or tantalum capacitors.

Tuning of the discriminators should be held to tighter tolerances (3 Hz for the 170 Hz discriminator and 5 Hz for the 850 Hz discriminator) because of the autostart circuits sensitivity to frequency error. The 2125 Hz tuned circuits are usually low in frequency initially and from 10 to 20 turns may have to be removed from the toroid to tune the circuit. When removing turns from a discriminator toroid, be sure to remove an equal number from each of the two windings to maintain the transformer balance.

The discriminator filters shift frequency slightly when all components are placed on the board as a result of interaction between the two filters. The net result is that center frequencies are shifted downward by approximately 8 Hz at 2125 Hz and 6 Hz at 2975 Hz. The procedure used at the factory to overcome this effect is to tune all discriminator toroids 10 Hz high in

frequency initially and to then trim the frequency as a final step in the alignment and test of the ST-6. This adjustment always involves addition of an extra tuning capacitor and is fairly easy to do at this late state. Alignment of the discriminators is easily checked using the tuning meter of the ST-6, since the peak readings of the meter occur at the frequencies of the discriminator toroids.

After all ten toroids and their associated capacitors have been tuned, they can be mounted on the circuit board. Be sure that the same capacitors used in the tuning of a given toroid are mounted with that toroid and not interchanged with another capacitor of the same marked value.

Alignment of the ST-6

Alignment of the ST-6 involves a limited number of preliminary checks and then adjustment of five trimming potentiometers on the circuit boards.

- (1) First, trace out all wiring between edge connectors and other components to assure that no wrong connections have been made. Double check connections to the board #5 connector from the power transformer as well as all power and ground connections to other connectors.
- (2) With NO circuit boards plugged in, apply power to the ST-6. If the fuse is inserted, the AC pilot lamp should glow. Use an AC voltmeter to measure the following voltages on edge connector #5:
 - (a) Between pins M & N - 26 VAC
 - (b) Between pins M & ground and pin N & ground - 13 VAC
 - (c) Between pins D & E - 250 VAC
 - (d) Between pins F & E and F & D - 125 VAC

Turn the power switch off after checking for the above voltages.

- (3) Insert only circuit board #5. Be sure to get it properly oriented in the edge connector. Place the Standby/Auto switch in the Auto position (open). Turn the power on and check to see that the AC pilot lamp and the Space lamp glow. Test with a DC voltmeter for the following voltages. (Note - the following notation will be used hereafter to designate pins on edge connectors: "3(K)" refers to pin No. K of the edge connector for circuit board No. 3. Similarly, "1-170 (10)" refers to pin 10 of the edge connector for circuit board No. 1, 170 Hz shift).
 - (a) 5(J) to ground - +12 volts
 - (b) 5(H) to ground - -12 volts
 - (c) 5(C) to ground - +170 volts
 - (d) Short the printer jack (either side) to ground and measure:
5(F) to ground - -155 volts
 - (e) Measure +12 volts to ground at the following locations: 1-850(2), 1-170(2), 2-850(11), 2-170(11), 3(K), 4(M), either coil terminal of the relay, and the +12 V connection to the meter-lamp-driver board.

- (f) Similarly, measure -12 volts to ground at the following locations: 1-850(11), 1-170(11), 2-850(10), 2-170(10), 3(L), 4(K).
- (g) Make sure that the following pins are grounded: 1-850(12), 1-170(12), 2-850(12), 2-170(12), 3(A), 4(A), 5(A).

Turn off the power switch after completing the above voltage checks. Set the loop pot (R6) to the maximum counter-clockwise position.

- (4) Now plug in all of the remaining circuit cards and turn the power on again. If a fuse blows or smoke appears, immediately shut off the power and locate the problem.
- (5) The input limiter stages can now be tested and aligned. Ground the audio input of the TU and connect a DC voltmeter to pin 8 of circuit board 1-170 (a zero-center meter with a -10 to +10 V scale is best). Adjust the trimming potentiometer on the board for 0 volts output. Not all of the SN72709N operational amplifiers will adjust to zero in this location. This does NOT indicate a defective operational amplifier. The range of adjustment of the trim-pot is intentionally restricted so that only the 709's with the lowest offset can be used in the input limiter stage. If the initial 709 will not adjust to zero, try "swapping" it with other of the 709's. Offset is not a critical parameter for any of the amplifiers except OA-101, OA-151. The limiter switch should be in the "ON" position for these adjustments.
- (6) Adjust the 1-850 board in the same manner.
- (7) The discriminators can now be aligned and tested.
 - (a) Set the meter switch to the tune position. Connect the signal generator to the audio input jack of the ST-6 and adjust the frequency until a peak is indicated on the tuning meter. Measure the frequencies of the two peaks of each discriminator and trim the tuning of each until the proper frequencies are measured -- remember to set the SHIFT switch to the correct position for the discriminator being tested.
 - (b) Tune to the center frequency of the Mark filter (2125 Hz) in the 850 Hz discriminator. Adjust the tuning meter potentiometer on the meter/lamp-driver board for a meter reading of 0.7.
 - (c) Tune the oscillator to the center of the space filter (2975 Hz) as indicated by a peak on the tuning meter. Adjust the trim-pot on the 850 Hz discriminator board (2-850) so that the tuning meter again reads 0.7.
 - (d) The 170 Hz filters will not indicate as high on the tuning meter as the 850 Hz units, but the technique is basically the same as outlined above - note the meter reading when peaked at 2125 Hz, peak at 2295 Hz and adjust trim-pot (2-170 board) for the same reading.

- (8) Next, the autostart sensitivity potentiometer on circuit board #4 is adjusted. Connect a DC voltmeter (again, preferably a zero-center meter) to test point 4 on circuit board #4. With the Normal - Reverse switch set for "Normal" and the autostart switches in the "Auto" position, apply a 2125 Hz signal to the ST-6 (the TU can be set for either shift - it is best to adjust for whichever shift you use the most). Now, detune the oscillator in either direction until the tuning meter indicates 80% of its peaked value (0.56 for 850 shift). Adjust the trim-pot on board #4 until the voltage at test point 4 flickers back and forth between plus and minus voltages. Note that if the autostart response switch, S4, is set for "Fast" mode, the Receive - Standby pilot lamps will also flicker back and forth if the adjustment is made with sufficient care. Choosing the setting of the autostart threshold is a matter of personal preference. Setting it too close to the peak frequency will mean turn-on's only for precise shifts; setting it too far away may result in turn-on's for noise, CW signals, etc. You may wish to change this adjustment after you have had some experience in operating the ST-6.

This completes the alignment of the ST-6 RTTY Terminal Unit.

Testing the ST-6

After tuning and alignment is completed test the operation of the individual features of the ST-6.

- (1) Check the operation of the input bandpass filters by connecting the oscillator to the AF input of the ST-6 and the oscilloscope to pin 8 of the proper board 1 for the shift being tested. With the limiter switch in the "OFF(AM)" position and the signal generator at 2125 Hz, adjust the oscillator amplitude until the scope display is a sine-wave. The response of the filter can now be observed by changing the oscillator frequency. Do not expect a perfectly flat response from either filter but do make sure that the output drops off above and below the 2125/2295 range or 2125/2975 range.
- (2) The limiter stage can be checked by repeating the above step with the limiter switch in the "ON(FM)" position. The scope display should be a square wave of constant amplitude with respect to frequency. Limiting will start with as little as a few millivolts audio input.
- (3) Operation of the discriminator stages and other stages has already been checked.
- (4) The anti-space circuit can be checked in the following manner: With the autostart switches in the "OFF" positions and the Normal-Reverse switch set to "Normal," connect the oscillator to the AF input and set it to 2125 Hz. The Mark pilot lamp should now be glowing. Flip the Normal-Reverse switch to "Reverse". The Space pilot lamp should come on for about a second and then go back to Mark. Without the anti-space feature, the TU would stay in Space condition continuously. The anti-space always works, whether or not the autostart mode is selected.

- (5) Next, check the autostart response. Connect the oscillator, set to 2125 Hz, to the AF input and set the switches to the following positions: "Normal," "Limiter-On," "Fast" response, "Autostart On" (S5), "Auto" (S3), "Auto" (S6, motor). The Mark pilot lamp and the Receive lamp should now be glowing. Disconnect the oscillator and the Standby lamp will come on in a few seconds, indicating that the autostart circuit has dropped out. The Receive lamp should again light approximately 1 or 2 seconds after reconnecting the oscillator to the input. With the response switch in the "Slow" position, a longer time will be required to activate or deactivate the autostart system -- typically, the time required for 5 or 6 RTTY characters.
- (6) With the slow-fast switch in the "slow" position, and the other switches as above, check the motor control by disconnecting the oscillator from the TU. Between 25 and 50 seconds after loss of signal (the exact time depends upon electrolytic capacitance tolerance), the autostart relay will open, removing power from the printer and placing the TU in standby open-loop status. (Note: The motor control will not operate in the Fast mode. All of the autostart is defeated in the AM mode.) The hold-on time of the motor control can be changed, if desired, by changing the value of C416 and/or R431 on card 4.
- (7) Note that with the Standby switch in "Standby," the printer is held in mark condition and there is no way that an incoming signal can be printed, automatically or manually, until this switch is thrown to the Auto position. Therefore, both the Receive and Standby lamps are lit whenever the TU is in Standby mode to serve as a reminder not to leave the TU in this mode.
- (8) The final test is to copy signals with the ST-6 hooked up to a receiver and printer.

ST-6 Voltage Measurements

The following approximate voltages can be used as a check if problems are experienced. All voltages were measured with a 20,000 ohms-per-volt Simpson 260 VOM. Voltages may vary as much as $\pm 20\%$ between units.

Supply Voltages

(No signal input, S3 in "STBY")

Voltage	Pin	Measured
" +20"	5(K)	+18.0
" +12"	5(J)	+10.7
" -12"	5(H)	-10.6
" -20"	5(L)	-18.0

Operational Amplifiers

Device	3	4	5	Pin Numbers	9	10	12	Condition
0A101	6.8	0	0		-10.0	*	8.3	No Signal
0A151	6.8	0	0		-10.0	*	8.3	No Signal
0A201	7.3	0	0		-10.0	**	8.0	Mark Signal
0A251	7.3	0	0		-10.0	**	8.0	Mark Signal
0A301	7.4 / 7.2	4.3 / -3.8	3.8 / -3.4		-10.0	4.2 / -3.8	7.9 / 8.1	Mark / Space
0A302	7.2	0	0.3		-10.6	9.6	6.7	Mark Signal
0A401	6.3 / 7.3	2.4	0 / 3.3		-9.3 / -10.6	-9.3 / 9.8	10.2 / 6.8	Mark / Space
0A402	6.3 / 7.4	3.2 / 0.5	2.7		-9.8 / -10.6	-9.6 / 9.9	10.2 / 6.9	Mark / No Signal
0A403	6.2 / 7.4	2.1	0 / 4.3		-9.7 / -10.6	-9.6 / 9.8	10.2 / 6.8	Mark / No Signal

* = Trim voltage at 0A101 and 0A151, pin 10 to zero with no signal.

** = Voltage at pin 10 of 0A201 and 0A251 varies between +4 to +8 volts between units.

Measure -10.6 volts at pin 6 of all IC's and +10.6 volts at pin 11 of all IC's.

ST-6 Voltage Measurements (Continued)

Transistors

Device	Emitter	Base	Collector	Test Condition
Q301	0	0.6 / -0.6	0.1 / 170.0	Mark / Space (instantaneous)
Q401	0	0.7 / -0.6	0 / 7.4	Mark / Space
Q402	-8.5 / 0*	-9.0 / 0*	-10.6	Mark / No Signal + 60 sec.
Q403	0	-0.7 / 0*	0 / -10.6*	Mark / No Signal + 60 sec.
Q404	-10.6	-10.1 / -10.6*	-10.6 / 8.2*	Mark / No Signal + 60 sec.
Q405	-10.6	-10.6 / -10.1*	10.9 / -10.6*	Mark / No Signal + 60 sec.
Q406	10.9	10.9 / 10.2	0 / 10.9	S3 "AUTO" / S3 "STBY"
Q501	10.9	11.4	17.0	S3 "STBY"
Q502	-10.6	-11.3	-18.0	S3 "STBY"
Q601	6.6 / 0.1	6.8 / 0.7	10.9	Mark / No Signal
Q602	0	-0.8 / 0.7	-0.1 / -20	Mark / No Signal
Q603	0	-0.8 / 0.7	18.0 / 0.1	Mark / No Signal

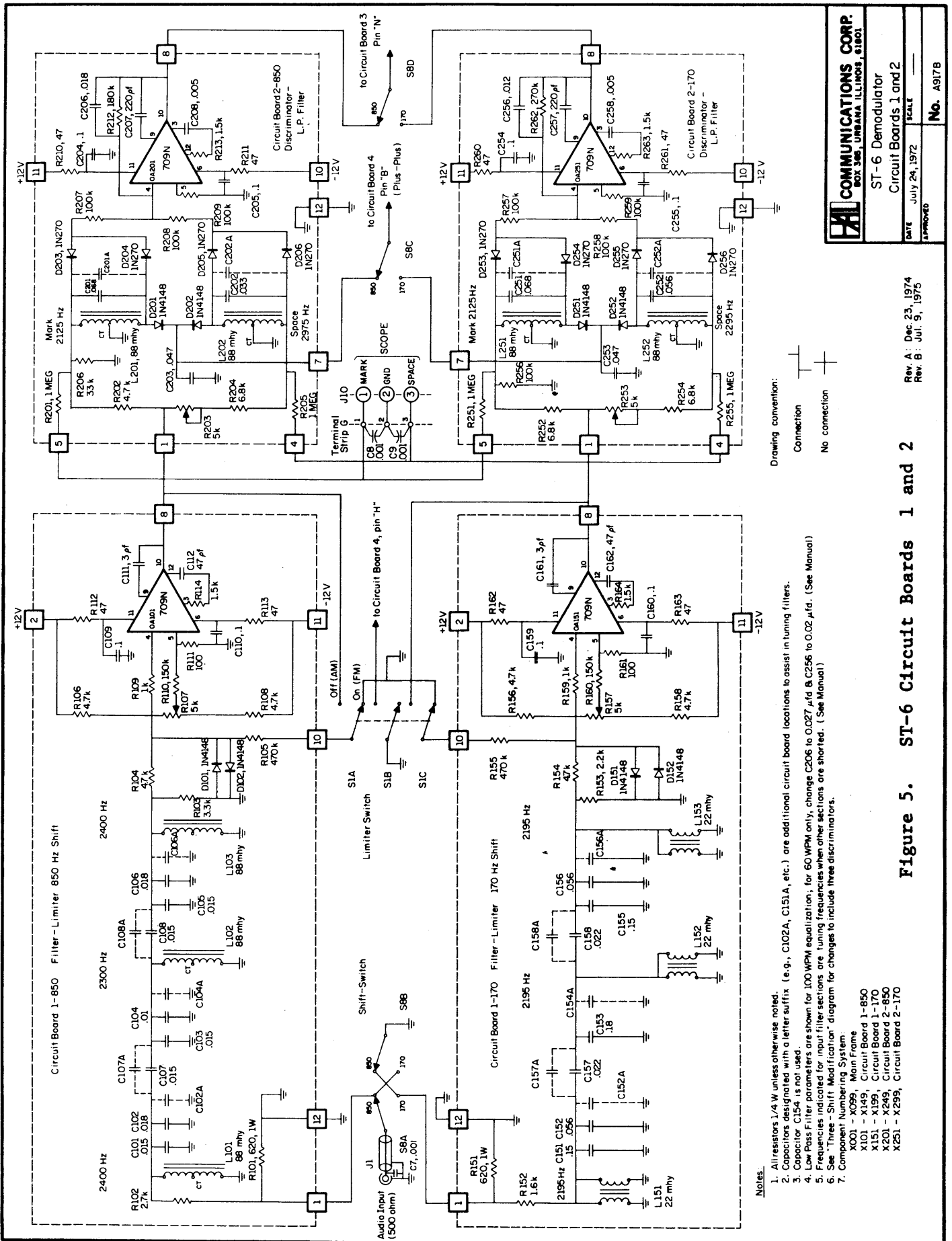
* = Make these measurements after the motor relay has switched off. The 170 volts will appear at the collector of Q301 on space condition until the anti-space operates (approximately 170 ms after space is applied).

Other Tests

Device	Pin	Measure	Condition
Normal - Reverse Switch	3(J)	1.7 / -1.4	Mark / Space
"Plus - Plus" Line	4(B)	6.8 / 0.8	Mark / No Signal
Anti-space Capacitor	C401	0 / 7.4	Mark / Space

6. SCHEMATIC AND CABINET WIRING DIAGRAMS

The schematic and cabinet wiring diagrams are shown on the following pages.



- Notes:
1. All resistors 1/4 W unless otherwise noted.
 2. Capacitors designated with a letter suffix (e.g., C102A, C151A, etc.) are additional circuit board locations to assist in tuning filters.
 3. Capacitor C154 is not used.
 4. Low Pass Filter parameters are shown for 100 WPM equalization; for 60 WPM only, change C206 to 0.027 μ f and C256 to 0.02 μ f.
 5. Frequencies indicated for input filter sections are tuning frequencies when other sections are shorted. (See Manual)
 6. See "Three-Shift Modification" diagram for changes to include three discriminators.
 7. Component Numbering System:
 X001 - X099, Main Frame
 X101 - X149, Circuit Board 1-850
 X151 - X199, Circuit Board 1-170
 X201 - X249, Circuit Board 2-850
 X251 - X299, Circuit Board 2-170

Drawing convention:
 Connection
 No connection

Figure 5. ST-6 Circuit Boards 1 and 2

COMMUNICATIONS CORP. BOX 385, URBANA, ILLINOIS, 61801	
ST-6 Demodulator	
Circuit Boards 1 and 2	
DATE	July 24, 1972
APPROVED	SCALE
REV. A	Dec. 23, 1974
REV. B	Jul. 9, 1975
No. A917B	

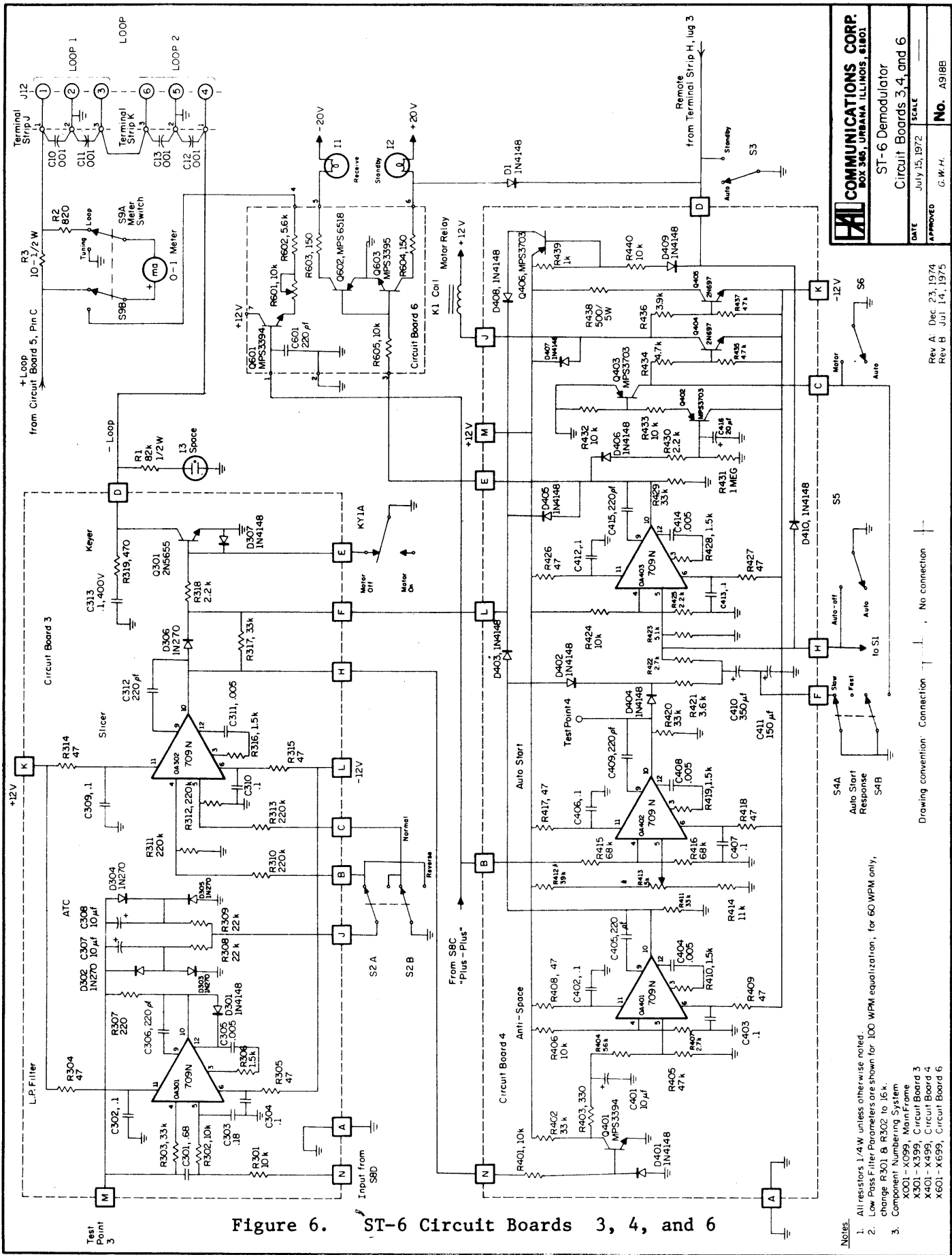


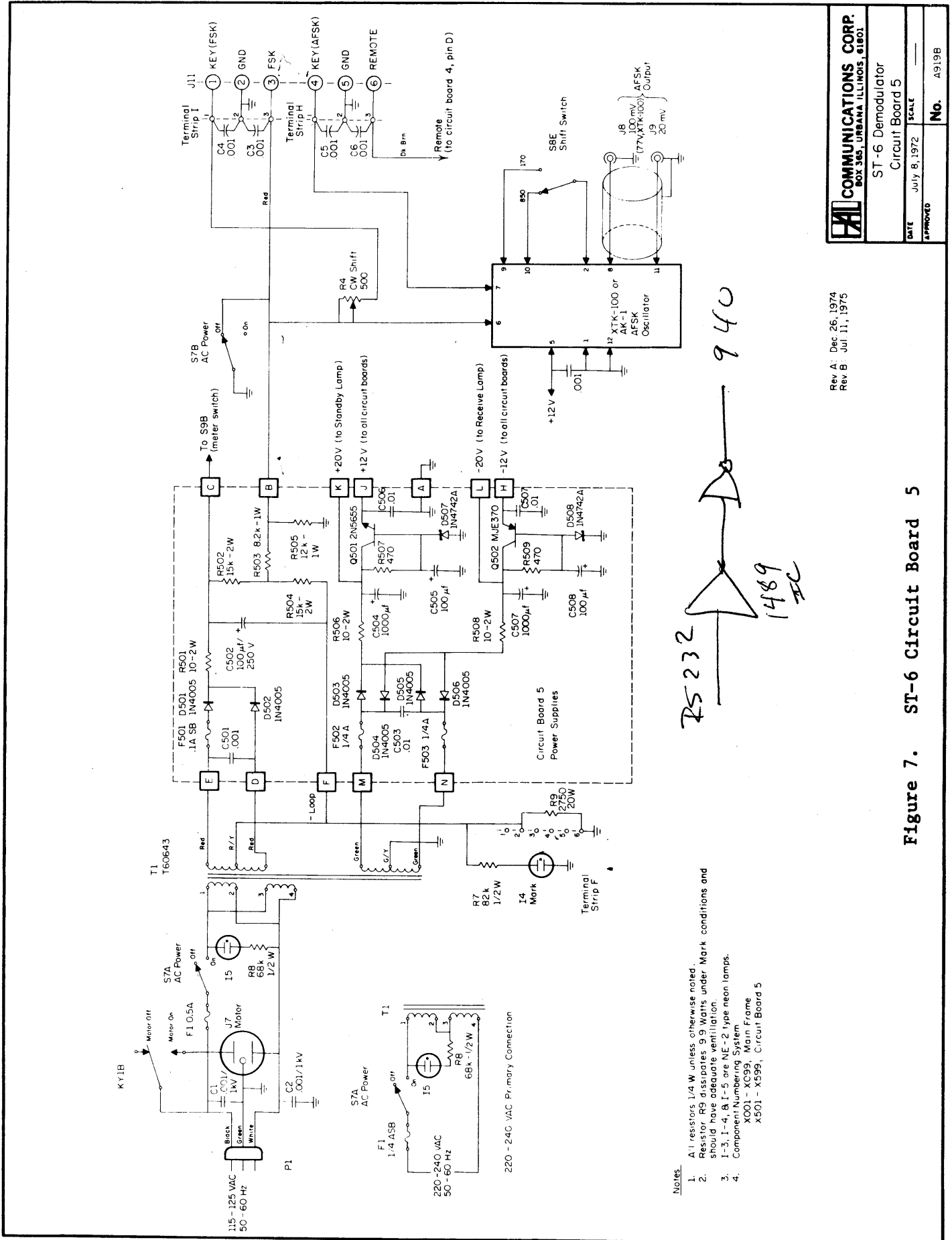
Figure 6. ST-6 Circuit Boards 3, 4, and 6

	COMMUNICATIONS CORP. BOX 365, URBANA, ILLINOIS, 61801
	ST-6 Demodulator Circuit Boards 3, 4, and 6
DATE: July 15, 1972	SCALE:
APPROVED: G.W.H.	No. A918B

REV A: Dec 23, 1974
 REV B: Jul 14, 1975

Drawing convention: Connection No connection

- NOTES:
- All resistors 1/4W unless otherwise noted.
 - Low Pass Filter Parameters are shown for 100 WPM equalization; for 60 WPM only, change R301 & R302 to 16k.
 - Component numbering System:
 X001 - X099, Main Frame
 X301 - X399, Circuit Board 3
 X401 - X499, Circuit Board 4
 X601 - X699, Circuit Board 6

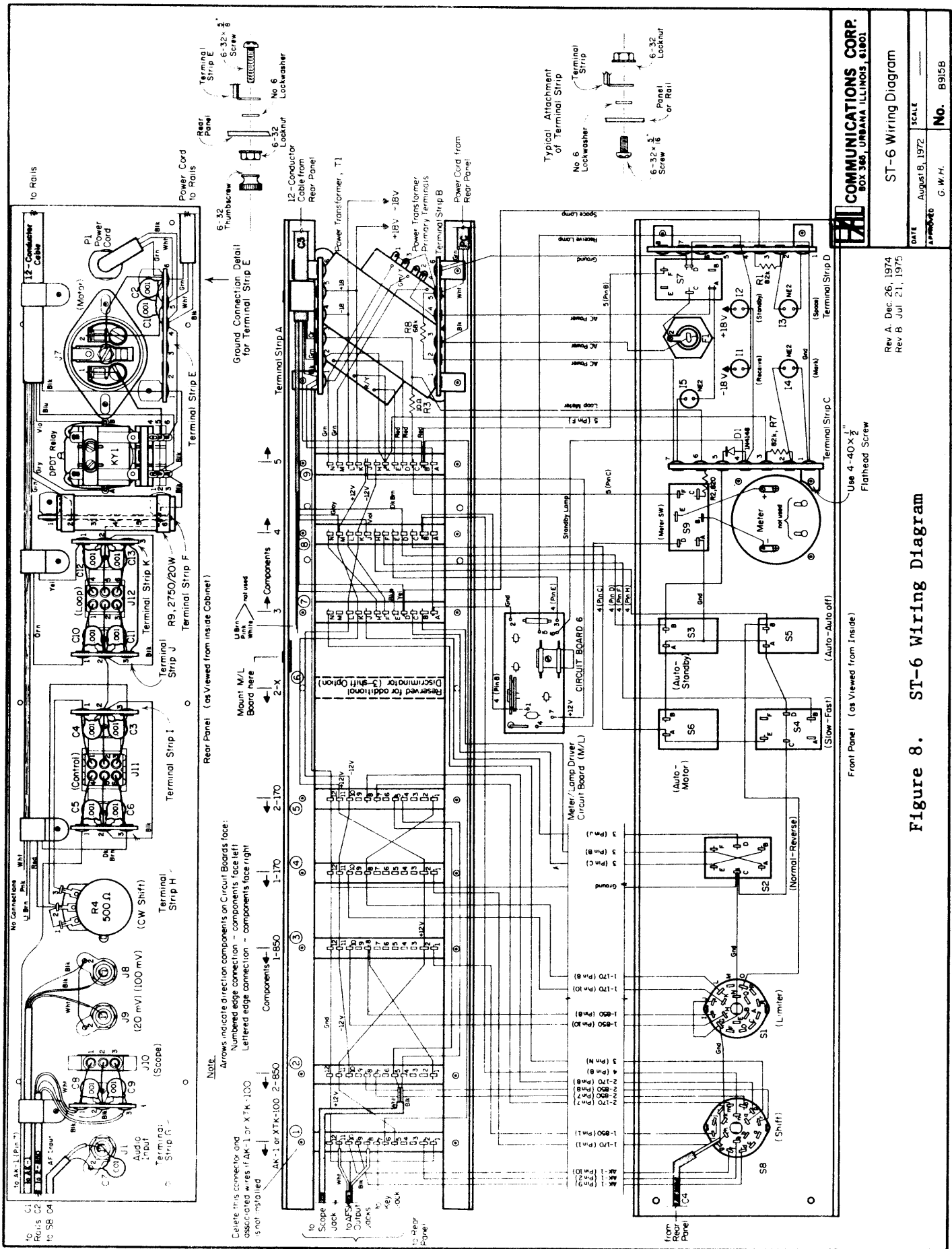


- Notes:
1. All resistors 1/4 W unless otherwise noted.
 2. Resistor R9 dissipates 9.9 Watts under Mark conditions and should have adequate ventilation.
 3. 1-3, 1-4, 8, 1-5 are NE-2 type neon lamps.
 4. Component Numbering System: X001 - X099, Main Frame; X501 - X599, Circuit Board 5

Rev A: Dec 26, 1974
 Rev B: Jul 11, 1975

	COMMUNICATIONS CORP. BOX 365, URBANA, ILLINOIS, 61801
	ST-6 Demodulator Circuit Board 5
DATE July 8, 1972	SCALE _____
APPROVED _____	No. A919B

Figure 7. ST-6 Circuit Board 5



COMMUNICATIONS CORP.
 BOX 365, URBANA, ILLINOIS, 61801

Rev A. Dec. 26, 1974
 Rev B. Jul. 21, 1975

DATE August 8, 1972
 APPROVED G. W. H. No. 8915B

ST-6 Wiring Diagram
 SCALE

Figure 8. ST-6 Wiring Diagram

7. CABINET AND CIRCUIT BOARD PHOTOGRAPHS

The photographs on the following pages show the position of the components on the circuit boards, and the internal cabinet wiring.

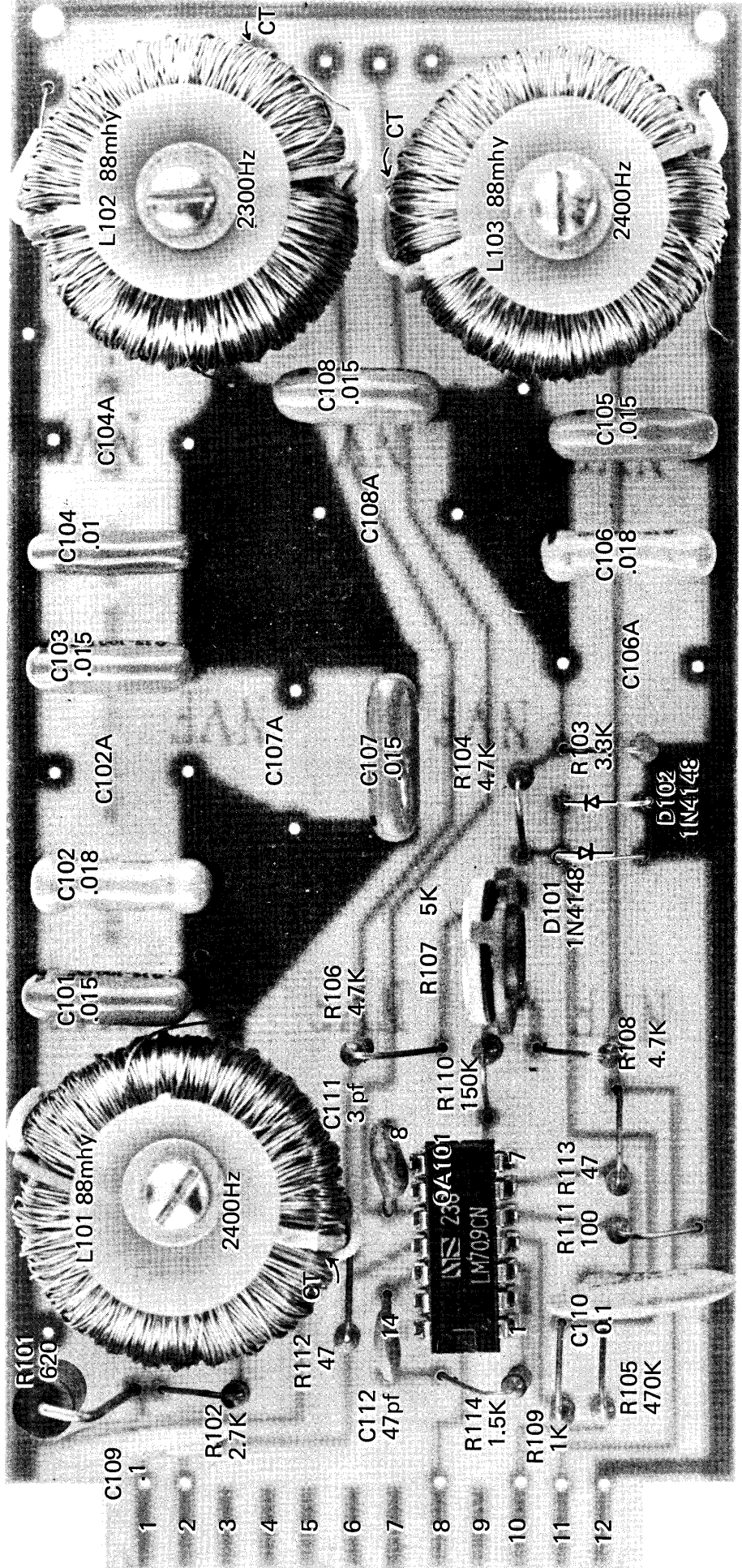


Figure 9
Circuit Board No. 1-850 Pictorial

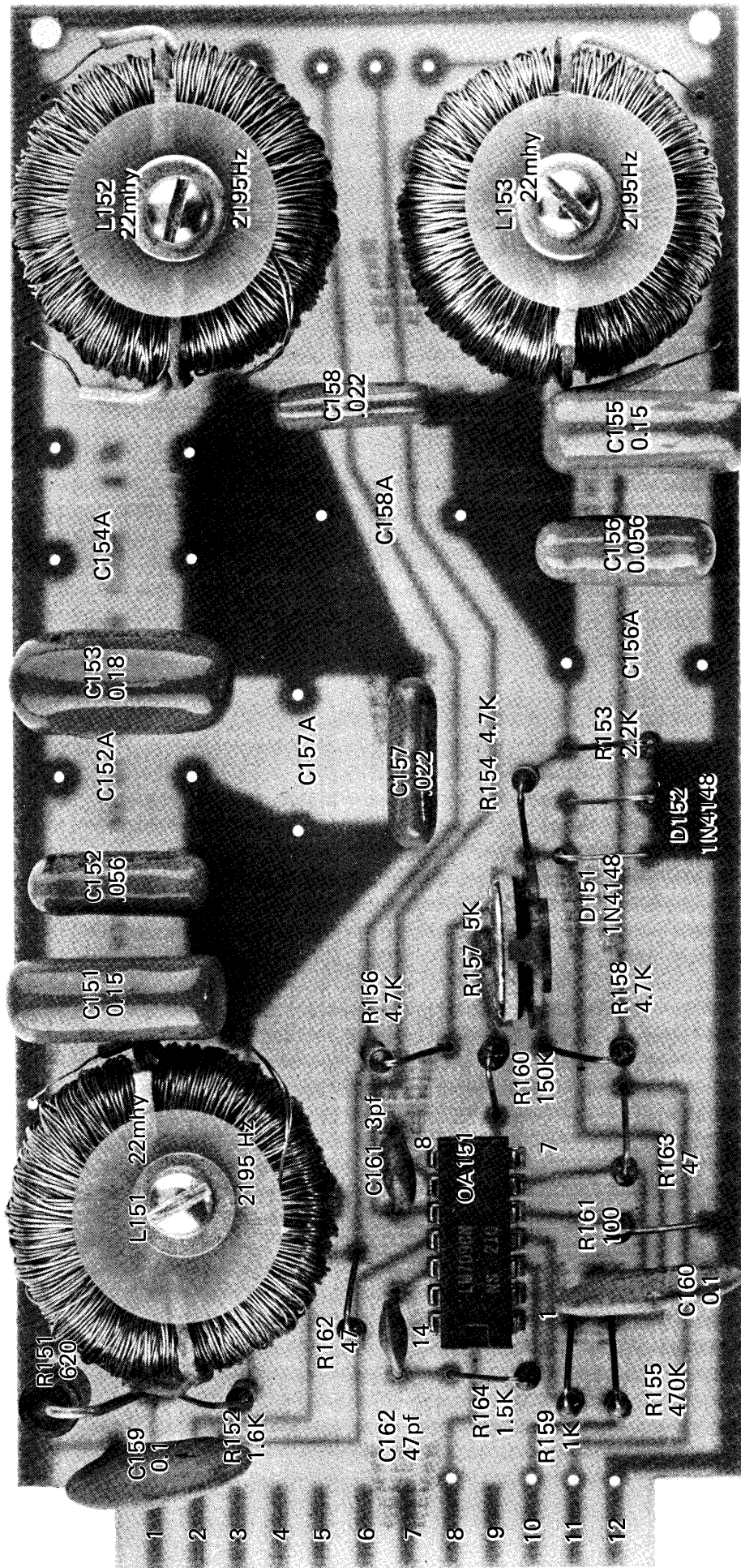


Figure 10
Circuit Board No. 1 - 170 Pictorial

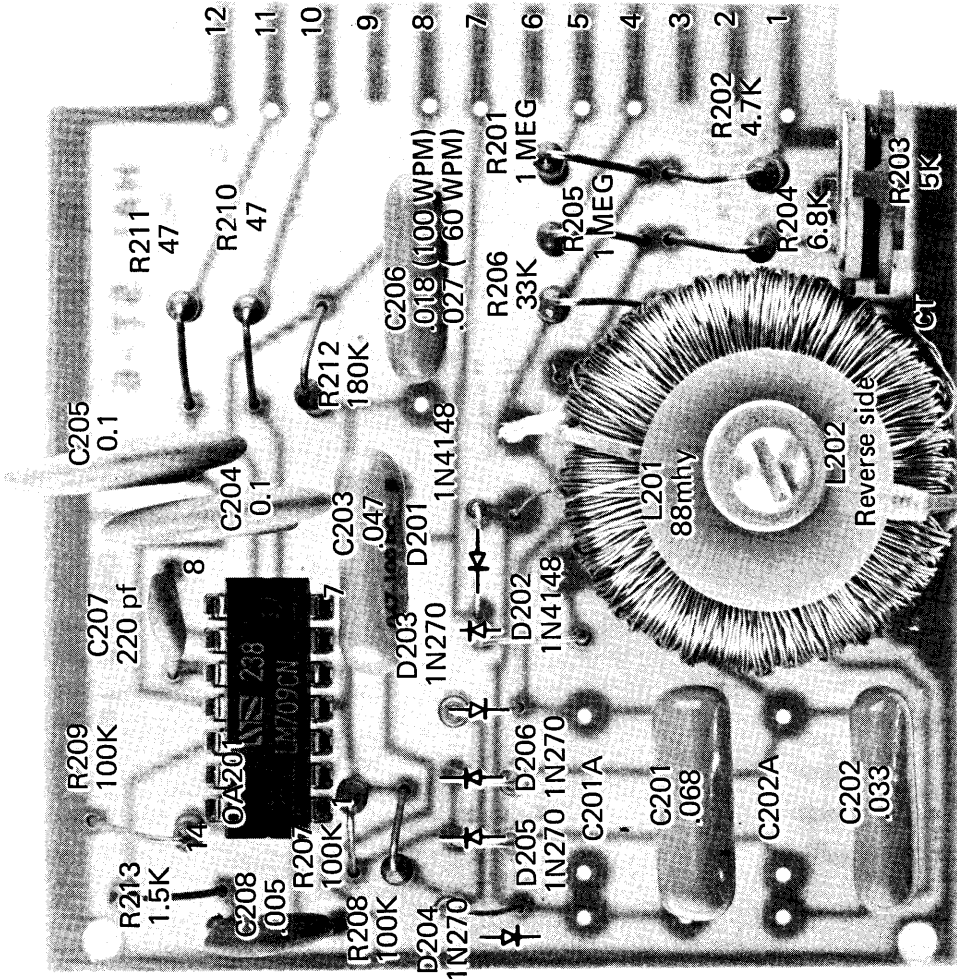


Figure 11
Circuit Board No. 2 - 850 Pictorial

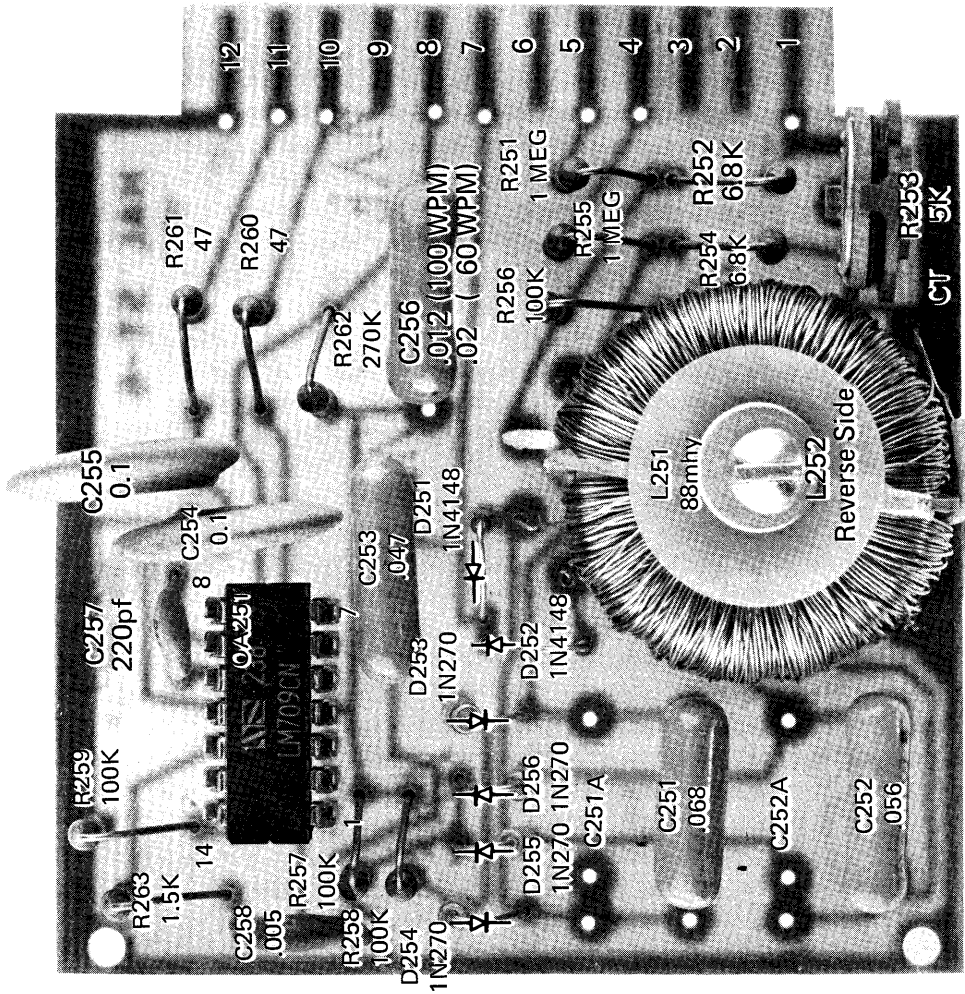


Figure 12
Circuit Board No. 2 - 170 Pictorial

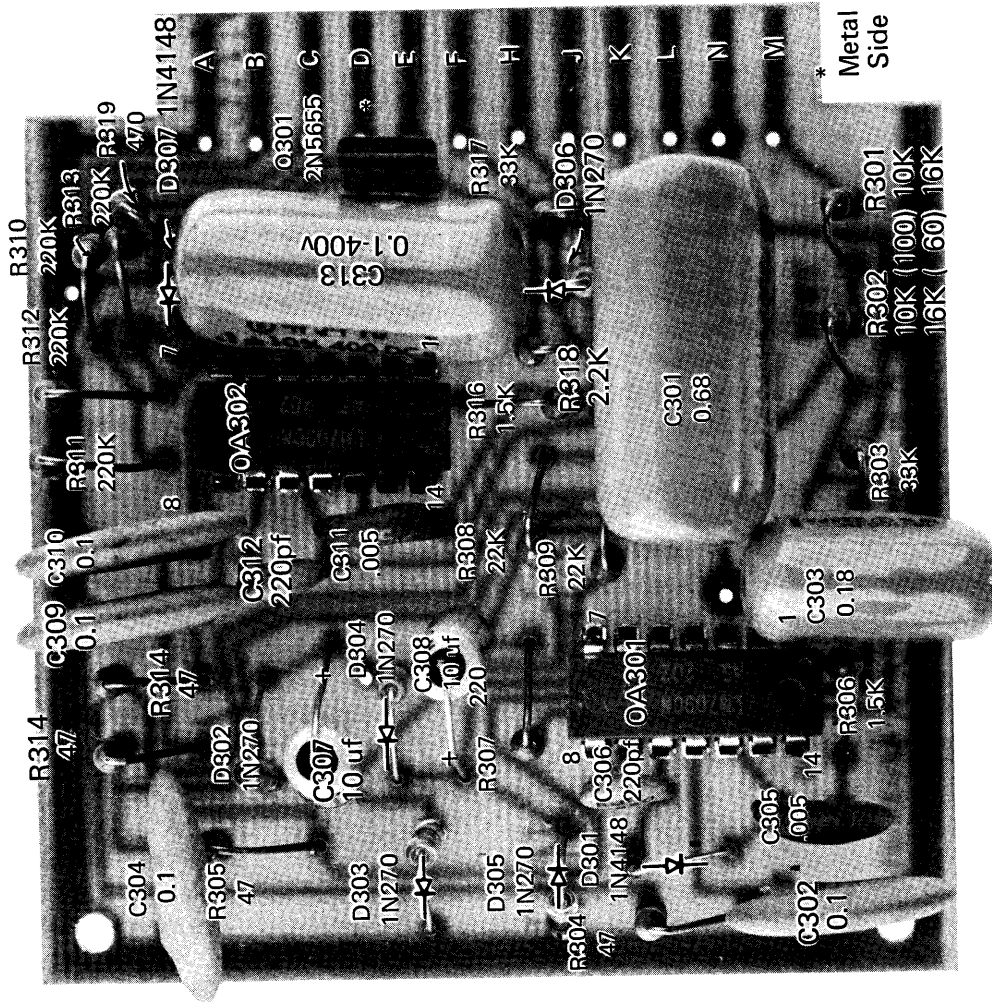


Figure 13
Circuit Board No. 3 Pictorial

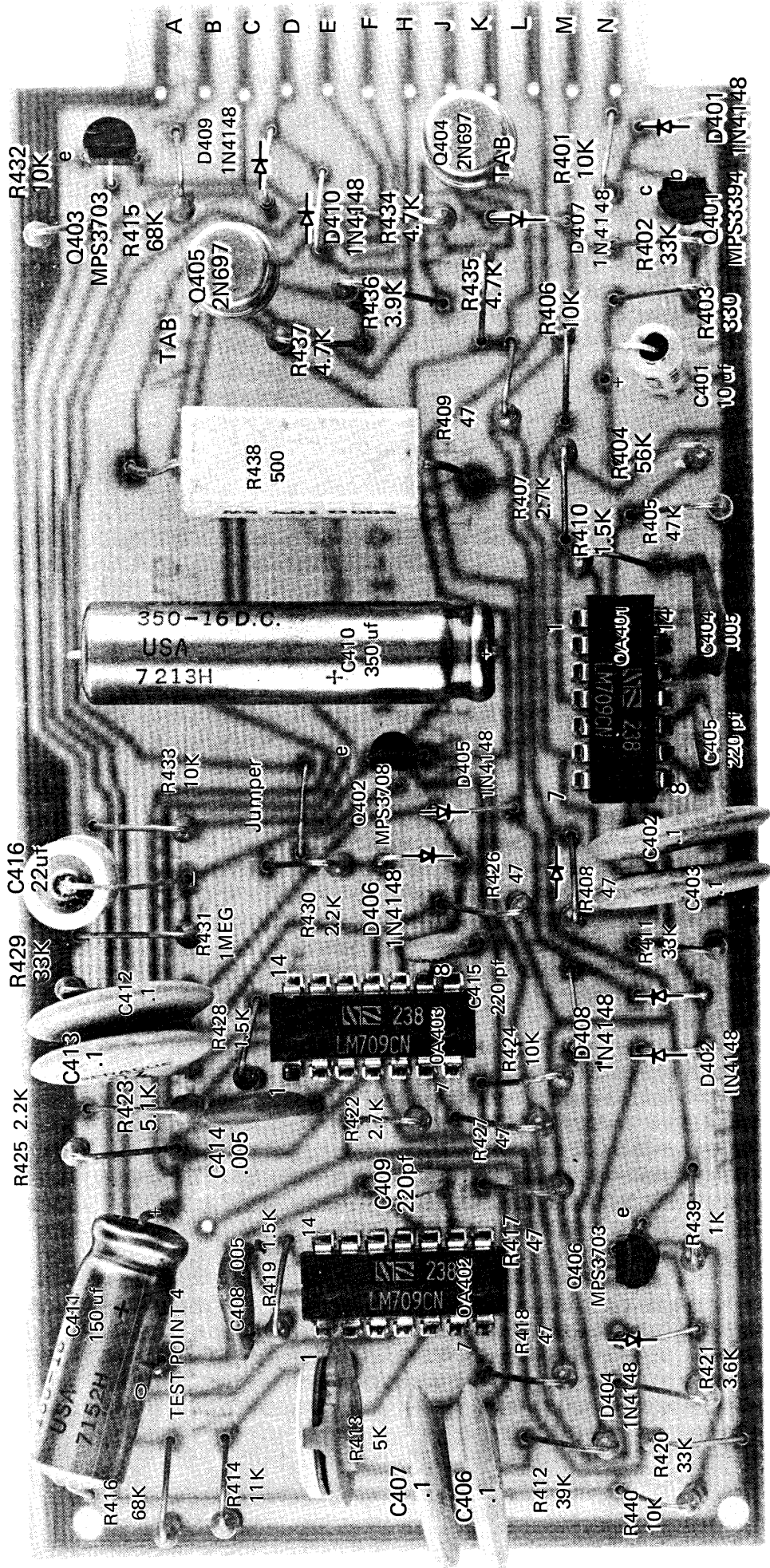


Figure 14
Circuit Board No. 4 Pictorial

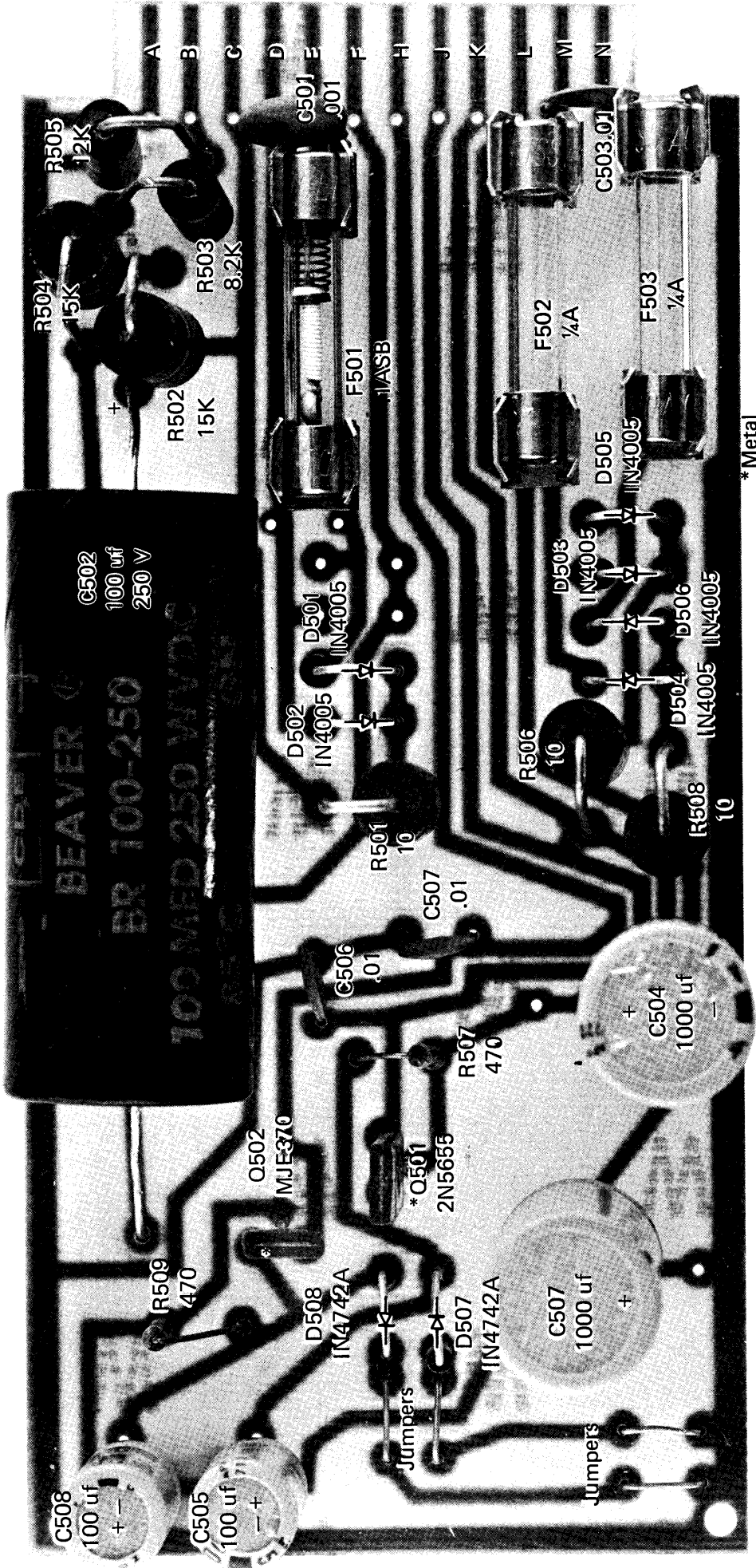


Figure 15
Circuit Board No. 5 Pictorial

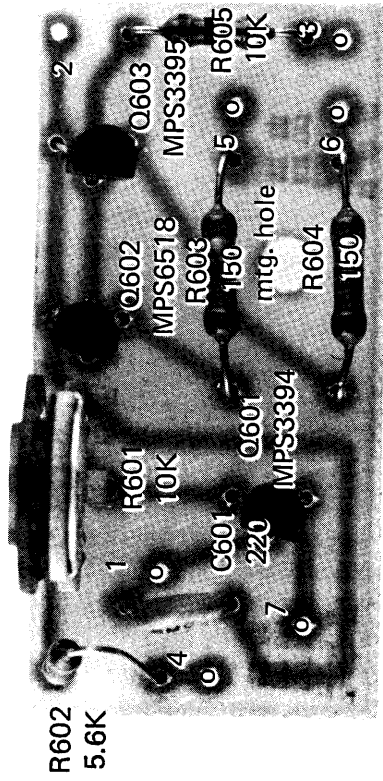


Figure 16
Circuit Board No. 6 Pictorial

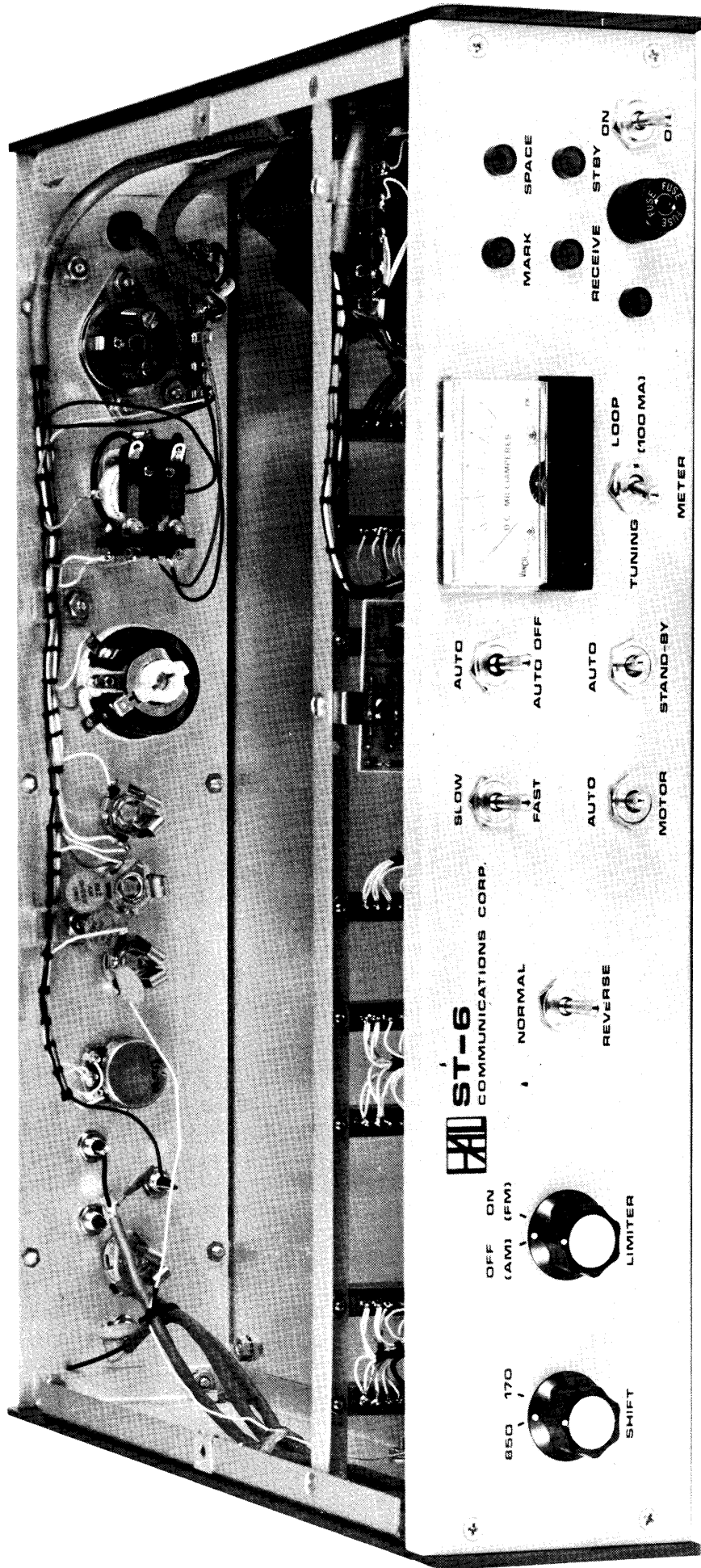


Figure 17
Cabinet Pictorial

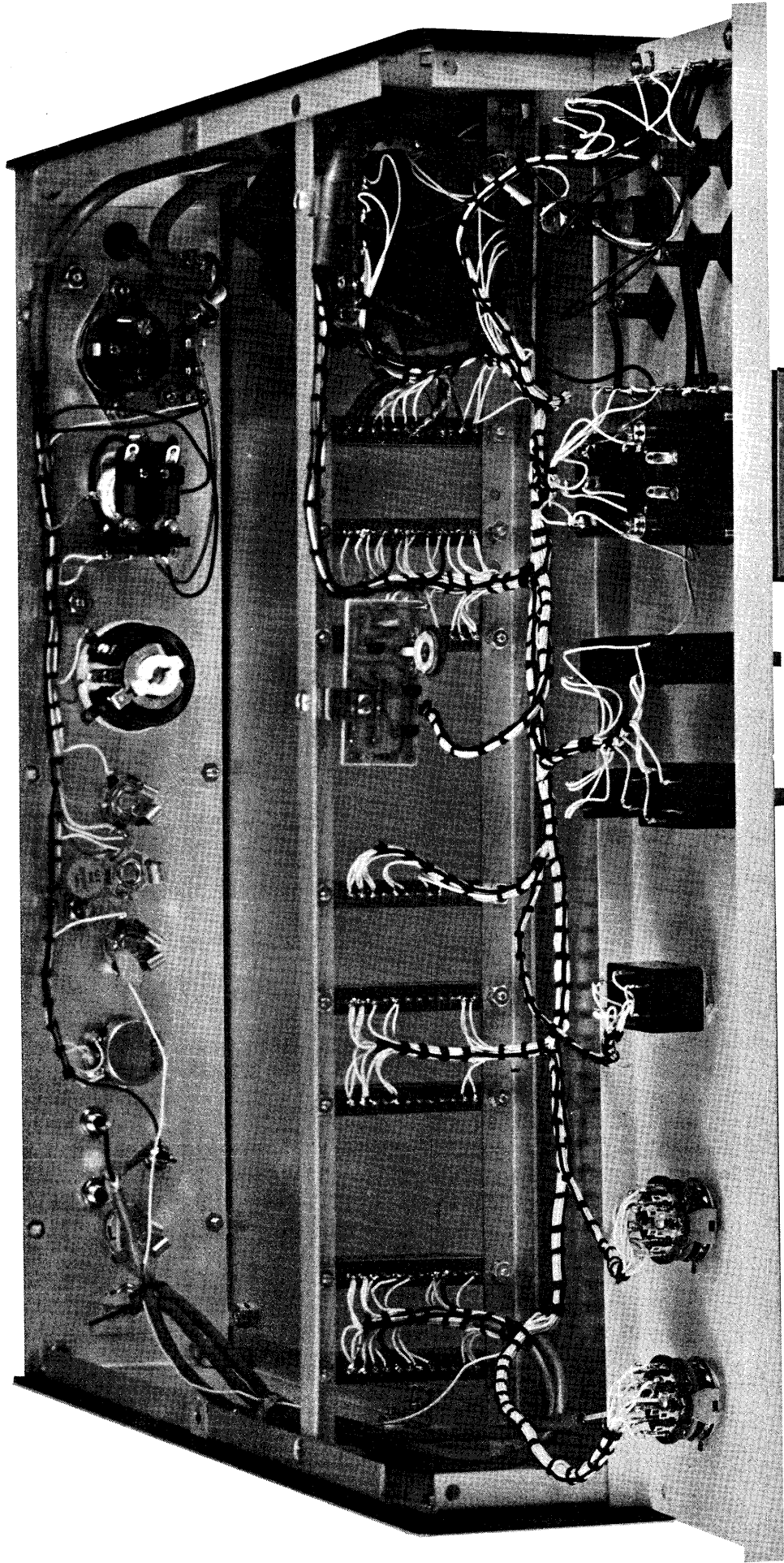


Figure 18
Cabinet Pictorial

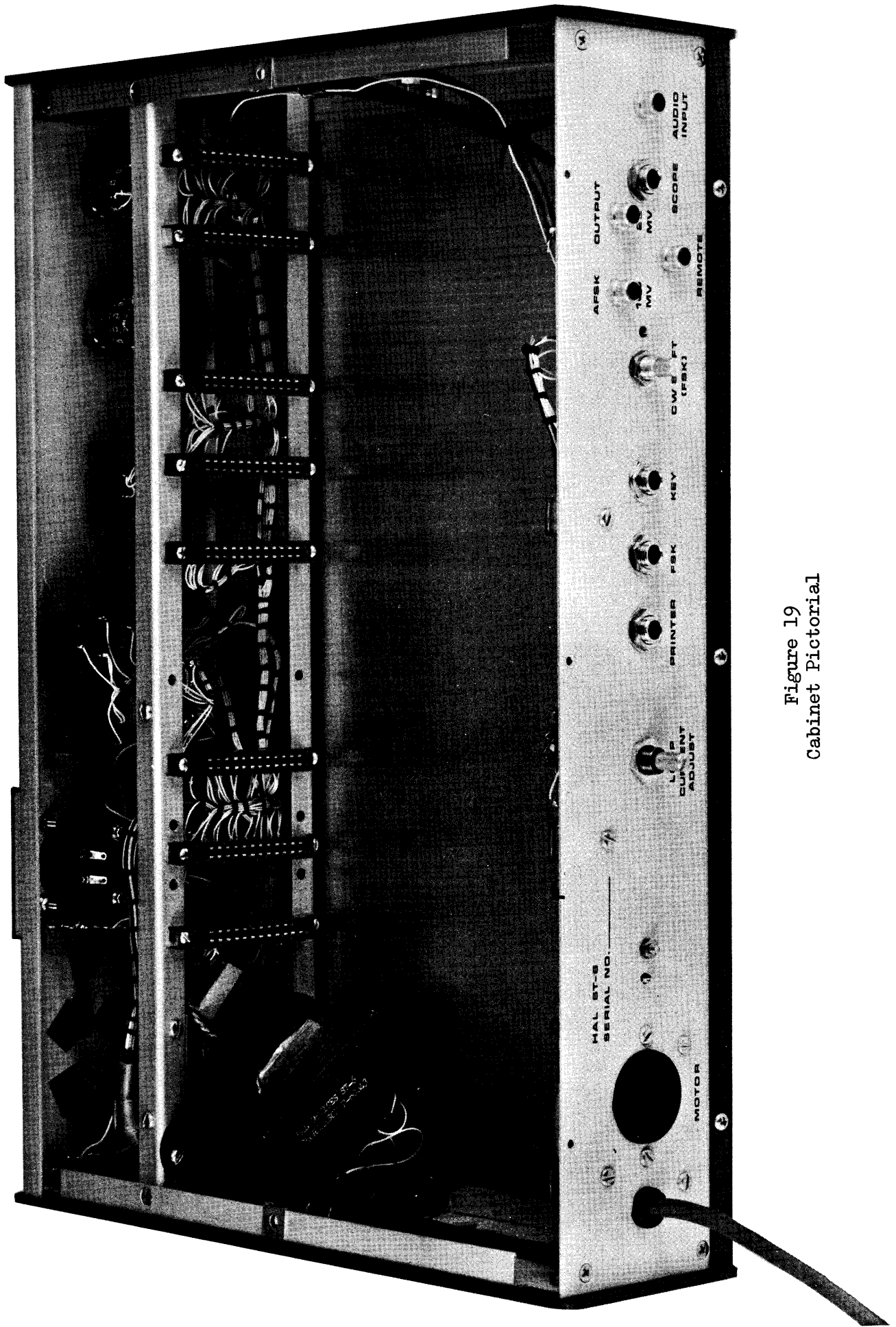


Figure 19
Cabinet Pictorial

8. PARTS LIST

Component	Total Used	(Quantities used on circuit boards)						Cabinet	
		1 170	1 850	2 170	2 850	3	4		5
Resistors, 1/2watt, 10%:									
10 ohm (1/2watt)	1								1 (Loop Current Mtr.)
47 ohm	18	2	2	2	2	4	6		
100 ohm	2	1	1						
150 ohm	2								2
220 ohm	1					1			
330 ohm	1						1		
470 ohm	3					1		2	
820 ohm	1								
1000 ohm	3	1	1				1		1 (Loop Current Mtr.)
1500 ohm	9	1	1	1	1	2	3		
2200 ohm	4	1				1	2		
2700 ohm	3		1				2		
3300 ohm	1		1						
3900 ohm	1						1		
4700 ohm	10	3	3		1		3		
5600 ohm	1								1
6800 ohm	3			2	1				
10 K	9					2	6		1
						(100wpm)			
22 K	2					2			
33 K	7				1	2	4		
39 K	1						1		
47 K	1						1		
56 K	1						1		
68 K (1-1/2w, 2-1/2w)	3						2 (1/2w)		1 (Neon dropping) (1/2w)
82 K (1/2watt)	2								2 (Neon dropping)
100 K	7			4	3				
150 K	2	1	1						
180 K	1				1				
220 K	4					4			
270 K	1			1					
470 K	2	1	1						
1 megohm	5			2	2		1		
Resistors, 5%:									
620 ohm (1 watt)	2	1	1						
1600 ohm	1	1							
3600 ohm	1						1		
5100 ohm	1						1		
11 K	1						1		
16 K	2								2 (60wpm)
Resistors, 10%, 1 and 2 Watt:									
10 ohm (2 watt)	3							3	
8200 ohm (1 watt)	1							1	
12 K (1 watt)	1							1	
15 K (2 watt)	2							2	

Component	Total Used	(Quantities used on circuit boards)								Cabinet
		1	1	2	2	3	4	5	6	
		170	850	170	850					
Power Resistors:										
500 ohm (5 watt)	1						1			
2750 ohm (20 watt)	1									1
Potentiometers:										
500 ohm (Panel Mtg.)	1									1
5 K (PC Mtg-trim)	5	1	1	1	1		1			
10 K (" " ")	1								1	
Capacitors, Disc Ceramic:										
3 pf	2	1	1							
47 pf	2	1	1							
220 pf	8			1	1	2	3		1	
0.001 mfd (1 kV)	14							1		13
0.005 mfd	7			1	1	2	3			
0.01 mfd	3							3		
0.1 mfd	18	2	2	2	2	4	6			
Capacitors, Mylar:										
0.01 mfd	1		1							
0.012 mfd	1				1(100wpm)					
0.015 mfd	5		5							
0.018 mfd	3		2			1(100wpm)				
0.02 mfd (200 V)	1					1(60wpm)				
0.022 mfd	2	2								
0.027 mfd	1					1(60wpm)				
0.033 mfd	1					1				
0.047 mfd	2			1	1					
0.056 mfd	3	2		1						
0.068 mfd	2			1	1					
0.10 mfd (400 V)	1						1			
0.15 mfd	2	2								
0.18 mfd	2	1					1			
0.68 mfd	1						1			
Capacitors, Electrolytic:										
10 mfd / 15 V	3					2	1			
20 mfd / 15 V	1						1			
100 mfd / 25 V	2							2		
100 mfd / 250 V	1							1		
150 mfd / 16 V	1							1		
350 mfd / 16 V	1							1		
1000 mfd / 25 V	2								2	
Semiconductors, Diodes:										
1N270 Germanium	13			4	4	5				
1N4148 Silicon(S)	21	2	2	2	2	2	10			1 (Remote Switch)
1N4742 Zener	2								2	
1N4005 (600 PIV Silicon)	6								6	

Component	Total Used	(Quantities used on circuit boards)								Cabinet
		1	1	2	2	3	4	5	6	
		170	850	170	850					
Semiconductors, Integrated Circuits:										
709N	9	1	1	1	1	2	3			
Semiconductors, Transistors:										
2N697	2						2			
2N5655	2					1		1		
MJE370	1							1		
MPS3394	2						1		1	
MPS3395	1								1	
MPS3703	3						3			
MPS6518	1								1	
Connectors:										
12 Pin Edge Conn.	7	1	1	1	1	1	1	1		
Phono Jack	1									1
Phono Plug	1									1 (Mate above)
3 pin conn. (male)	1									1
3 pin conn. (female)	2									2 (Mate above)
6 pin conn. (male)	3									3
6 pin conn. (female)	3									3 (Mate above)
Conn. pins (male)	21									21
Conn. pins (female)	24									24
117 VAC female socket	1									1
14 pin IC sockets	9	1	1	1	1	2	3			
Switches:										
DPDT Toggle	4									4
SPST Toggle	3									3
6PDT Rotary	2									2
DPDT, 24 VDC Relay	1									1
Coils, Transformers:										
88 mhy toroids	10	3	3	2	2					
T-60643 Power transformer	1									1
Circuit Boards:										
Circuit board #1	2	1	1							
Circuit board #2	2			1	1					
Circuit board #3	1					1				
Circuit board #4	1						1			
Circuit board #5	1							1		
Circuit board #6	1								1	
Miscellaneous Components:										
0.100 Amp Fuse S.B.	1							1		
0.250 Amp Fuse	2							2		
0.500 Amp Fuse	1									1
Fuse Holder	1									1
Fuse Clips	6							6		

Component	Total Used	(Quantities used on circuit boards)						Cabinet	
		1	1	2	2	3	4		5
		170	850	170	850				
Miscellaneous Components:									
Power Cord	1								1
Lamp bezels	5								5
Lamp bezel clips	5								5
Neon lamps	3								3
Incandescent lamps	2								2
Meter, 0-1 ma	1								1
Strain relief	1								1
6 terminal tie- strips	4								4
8 terminal tie- strips	2								2
Cable clamps	8								8
Construction manual	1								
Hardware:									
4-40 x 1/4" screws	7						6	1	
4-40 x 1/2" screws	1								1
4-40 nuts	22						6	1	15
#4 Lockwashers	28						12	1	15
6-32 x 3/4" screws	6	3	3						
6-32 x 1/2" screws	2			1	1				
6-32 lock-nuts	22								22
#6 lockwashers	33	3	3	1	1				25
#6 Flatwashers	7								7 (Cable clamp)
Nylon washers	2			1	1				
Angle Bracket	1								1 (Mtg. No. 6 Board)
Knobs	2								2
4-40 x 1/2" screws	14								14
6-32 x 5/16" screws	19								19
6-32 x 1/2" flat- head	4								4
12 conductor cable 30"	30"								30"
2 cond. shielded cable	36"								36"
Hook-up wire	1-coil								X
6-32 x 5/8" screw	1								1
1/4" lockwashers	3								3
3 lug term. strip	5								5
6-32 thumb-nut	1								1
Toroid retainers (threaded)	8	3	3	1	1				
Toroid retainers (not-threaded)	2			1	1				

Note: Connectors, switches, and mounting hardware for the AK-1 and 425 Hz Discriminator are furnished with the respective kits and are not included in the ST-6 kit.

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.