



**INSTRUCTION
MANUAL**

**FREQUENCY SHIFT
CONVERTERS**

**MODELS
400 and 402**

Electrocom[®] INDUSTRIES

1105 NORTH IRONWOOD DRIVE, SOUTH BEND, INDIANA 46615 - U.S.A.

Burt J. Ste

ELECTROCOM INDUSTRIES

MODEL: 400

SER. NO.: 5284

CHANNEL 1 SETTING:

MARK 2125 HZ.

SPACE 2975 HZ.

Audio Input

0

Resistor Signal One

600Ω

Channel 1

set Tones preset 2125 Hz. → Automatically set
— set to standard 170 shift. —

Channel 2

Fixed mark freq. 2125 Hz.

Space freq. Varies with shift control knob.

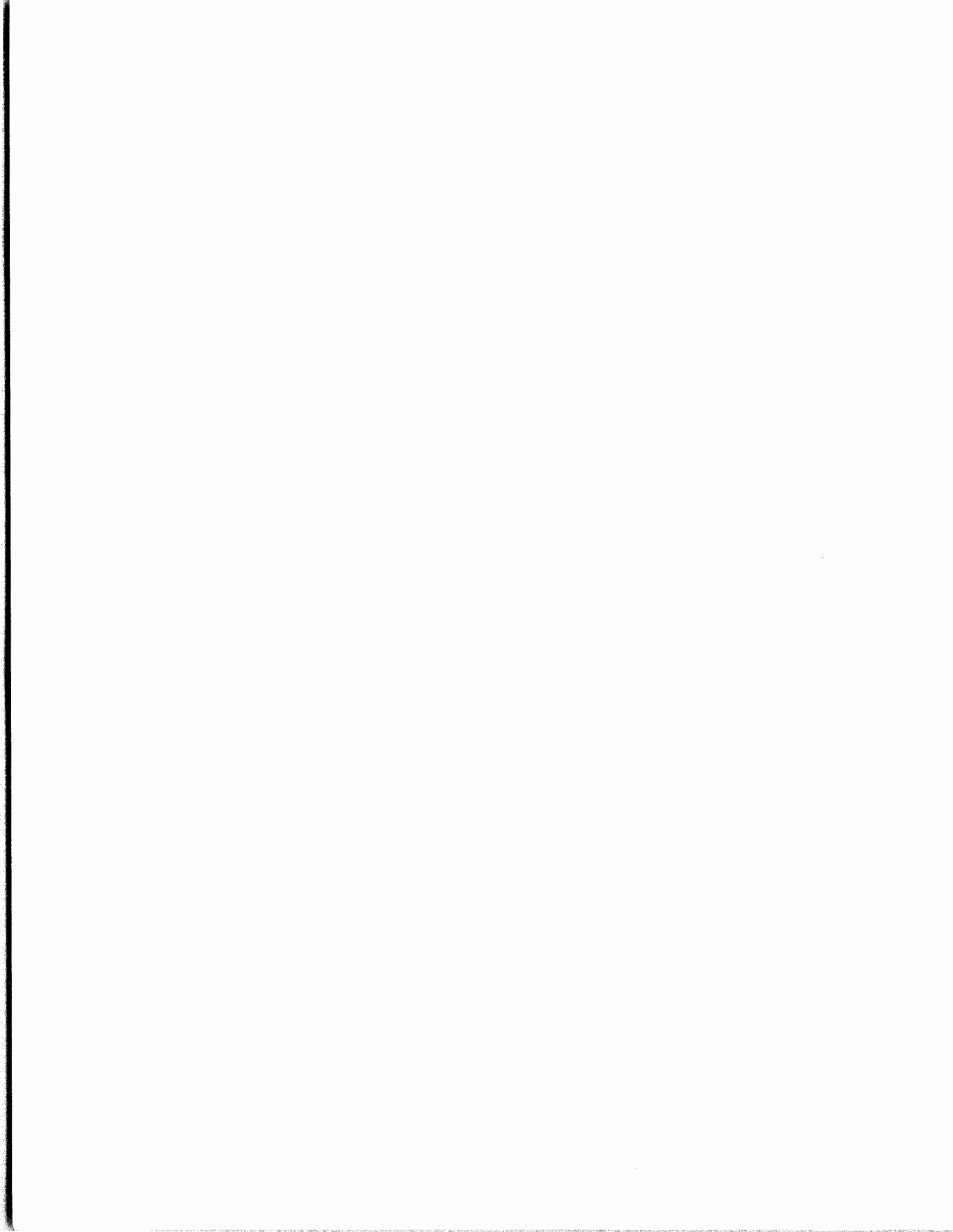
Space Low 2125 Hz to 1125 Hz.

1 High 2125 Hz to 3125 Hz

Lower SSB

mark 2125 Hz }
Space 2975 Hz } 850 shift

mark 2125 Hz }
Space 2295 Hz } 170 shift





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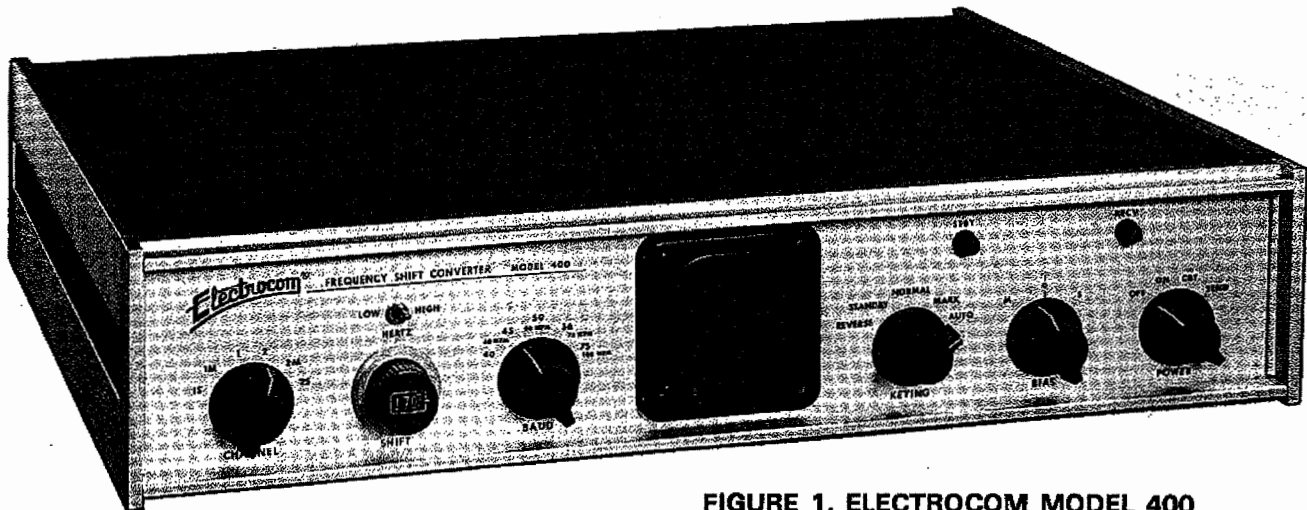


FIGURE 1, ELECTROCOM MODEL 400

SECTION 1, DESCRIPTION

1.1 GENERAL

The Electrocom® series 400 Frequency Shift Converters (Demodulators), Models 400 and 402, are designed primarily for radio teletypewriter operation on high frequency channels utilizing SSB transmitters and receivers. Since this mode of operation requires the most stringent performance capabilities, these units are equally well suited for vhf or microwave system operation. The many deluxe features contained within these units allow adaptation to practically any radio-teletype (RTTY) system. Both converters are ideal for continuous unattended monitoring, since "Autostart" circuitry turns the teleprinter motor on when valid teletype signals appear. The motor turns off after message completion, but loop current is maintained until the machine quietly stops. Afterwards, this current turns off to provide minimum standby power. The circuit time constants reject noise and cw keying, and sample the overall pulse duration of the received signals in order to determine if they may contain teletype information. False automatic starting is thereby reduced to a minimum.

The series 400 equipment contains optimum bandwidth, adjustable tone filter channels which may be set to any frequency in the range of 1000 to 3200 Hz. A ten turn digital knob displays an accurate readout of shift (Model 400) or tone frequency (Model 402). Ultimate long term stability is achieved by the use of precision tuned, temperature compensated, toroidal L-C filters. Performance is improved during fading and single channel interference by an automatic symmetry corrector (ASC) circuit which allows semi-diversity and mark or space only reception. C-mos logic provides low power consumption with high noise immunity. Other features include full wave precision linear detectors, a dynamic range greater than 60 db., antispaces and mark hold circuitry, a 2 inch CRT tuning indicator

and monitor, zero crossing solid-state motor switching, and a constant current selector magnet power supply. With the exception of the Cathode Ray Tube (CRT) used for the monitor display, the circuitry is completely solid-state. Monitor visibility is improved and CR tube life extended by an automatic intensity control circuit which adjusts trace brightness in proper contrast to ambient light, and by automatic blanking during signal absence. Provision has been included in the basic design for the internal addition of various optional accessories such as electronic signal regeneration, speed conversion, selective teleprinter motor control upon the reception of a predetermined sequence of characters (Select-call), idle line motor control, and an internal frequency shift tone keyer (Modulator) for use in transmitting RTTY signals.

The 400 equipment is attractively packaged in a functional cabinet ruggedly constructed from aluminum extrusions. Modular circuitry is contained on four plug-in printed circuit cards: the Demodulator, Logic, Monitor, and Power/Keyer. Additional space is allocated for Accessory and Modulator cards. These cards are manufactured from epoxy glass material, have plated through holes, and gold plated edge card connections in order to provide the highest reliability. They are mechanically positioned so that complete access to all test points and calibration adjustments is readily available by removing the cabinet covers. As a result, card extenders or other special fixtures are not required for servicing.

The front panel of the Model 400 contains one digital knob for selecting the amount of frequency shift, and a "Bias" control which is useful for correcting distorted signals. The Model 402 front panel contains two digital knobs which are used for selecting the mark and space tone frequencies. Although the "Bias" control has been omitted, an internal adjustment is included should system bias

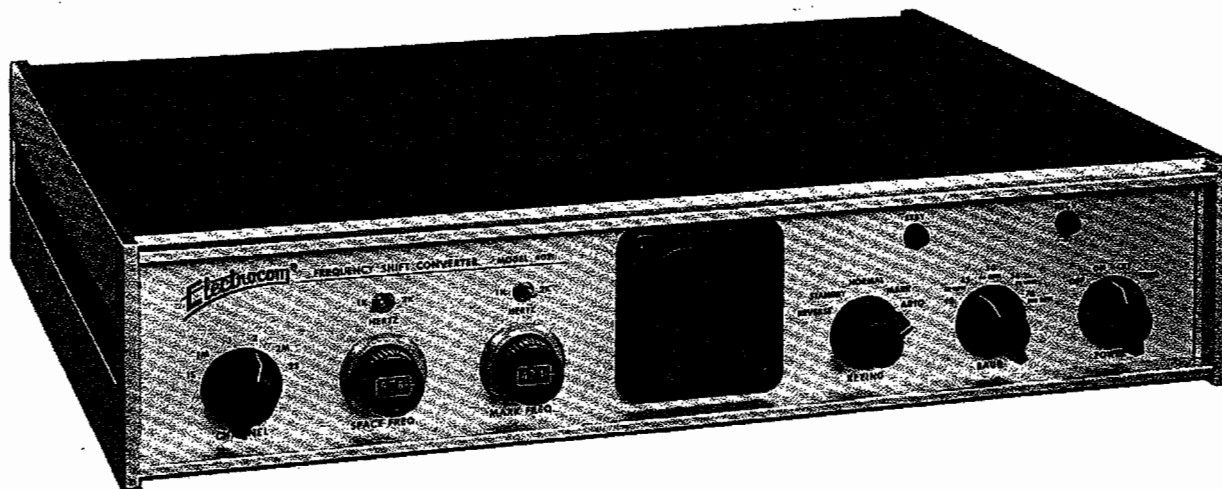


FIGURE 2, ELECTROCOM MODEL 402 FREQUENCY SHIFT CONVERTER

correction be necessary. The paragraphs which follow will further describe the versatility, reliability, simplicity of operation, and ease of maintenance of these units. Throughout this manual the term "400" refers to both models. When describing only one of these converters, the term "Model 400" or "Model 402" is used.

1.2 SPECIFICATIONS

INPUT IMPEDANCE: 600 ohm, unbalanced. Option #3, balanced input.

SENSITIVITY: Threshold 1 mv., full limiting 5 mv.

INPUT DYNAMIC RANGE: -50 to +20 dbm.

SHIFT: Continuously variable from 50 to 1000 Hz. (400), 50 to 2000 Hz. (402), and preset from 50 to 2200 Hz.

tone frequencies:

CHANNEL #1: Mark and Space frequencies internally adjustable from 1000 to 3200 Hz.

CHANNEL #2 (Model 400): Mark, 2125 Hz.; Space (LOW), 2125 to 1125 Hz.; Space (HIGH), 2125 to 3125 Hz.

CHANNEL #2 (Model 402): Mark and Space frequencies independently variable from 1000 to 3000 Hz.

CALIBRATION ACCURACY: ± 12 Hz. of reading.

MARK & SPACE FILTER SELECTIVITIES: 95 ± 10 Hz. at 3 db.

MONITOR/TUNING INDICATOR: 2 inch CRT.

RESPONSE TIME (NOMINAL): Mark-hold, 1.3 seconds; Autostart, 3.6 seconds; Motor turn off delay, 50 seconds.

MAXIMUM KEYING RATE: 75 bauds (100 wpm, 5 level Baudot code). Option #6, 110 bauds (100 wpm, 8 level ASCII code).

CURRENT OUTPUT: Neutral DC continuously variable from 20 thru 60 ma. into any loop resistance from 0 to 1500 ohms. Current will remain constant regardless of loop resistance or power line voltage variations. Maximum resistance for 20 ma. loop is 5000 ohms. See Options #4 & #5 for polar current output.

VOLTAGE OUTPUT: EIA RS232C (-14 v. mark, +14 v. space), or MIL-STD-188C (+6 v. mark, -6 v. space).

POWER: 115 or 230 v. $\pm 15\%$ (rear panel switch selected), 50-400 Hz. 10 watts standby power with CRT off, 40 watts maximum.

OPERATING TEMPERATURE: 0 to 65° C. (32 to 149°F.)

PANEL: Clear anodized, etched aluminum finish with black figures.

CASE: Aluminum with clear anodized finish, textured dark grey covers and trim.

DIMENSIONS: 89 mm. (3.5 inches) high, 432 mm. (17 in.) wide, 356 mm. (14 in.) overall depth. Rack mounted model, Option #1, extends 327 mm. (12.875 in.) behind and 45 mm. (1.75 in.) forward of rack mounting surface. Panel width is 483 mm. (19 in.)

WEIGHT (less options): 6.01 Kg. (13.25 lbs.) net.

1.3 OPTIONS

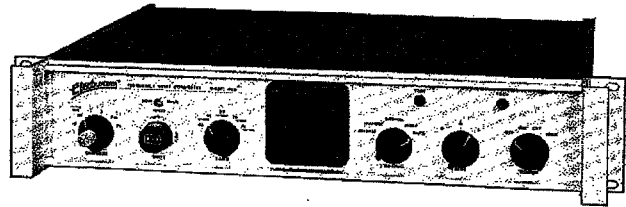
To add to the versatility of the series 400 converters, the following standard options are available:

OPTION #1 — Rack mounting adapter with handles. Normally supplied factory installed, but may be installed in the field.

OPTION #2 — Input filter and preamplifier assembly, less filters. The use of an optional input filter is often beneficial depending upon the characteristics of the communications receiver with which the "400" will be used. These input filters serve to reduce the bandwidth into the converter to the minimum required for a particular tone pair, thereby reducing unwanted noise and interference. Since various tone combinations are readily available, this option provides for mounting up to three plug-in filters within the cabinet. A concentric knob of the "Channel" selector allows these filters to be bypassed completely, or for any one of them to be switched into the circuit. In addition to the switching feature, a preamplifier is installed between the audio input and the filter to provide isolation, assure proper impedance matching, and compensate filter insertion loss.

OPTION #3 — Balanced 600 ohm input, transformer isolated.

OPTION #4 — Polar current output providing DC current adjustable from ± 8 to ± 30 ma. into any loop resistance from 0 to 1000 ohms, and ± 8 to ± 20 ma. into a maximum of 2700 ohms.



**FIGURE 3, ELECTROCOM MODEL 400
CONTAINING OPTIONS 1 AND 2**

Current will remain constant regardless of power line variations.

OPTION #5 — Polar current output providing DC current adjustable from ± 8 to ± 40 ma. into any resistance from 0 to 1000 ohms and ± 8 to ± 20 ma. into a maximum of 4000 ohms. Current will remain constant regardless of resistance or power line variations.

OPTION #6 — Maximum keying rate of 110 bauds for optimum performance with teleprinters using the ASCII code (100 wpm).

SECTION 2, INSTALLATION

2.1 UNPACKING

Carefully remove the equipment from the packaging carton and examine for any possible damage which may have occurred during transit. The inside of the unit may be inspected by removing the two screws on the rear flange of the cover, and sliding the cover to the rear of the unit. Both top and bottom covers are removed in the same manner. Check to be certain that the PC Cards are firmly installed in their sockets and that the hold down screws through the ends of these boards are tight. Inspect for any loose parts. Check to see that all control knobs and switches turn properly. The "Bias" control which is contained on the front panel of the Model 400, has a detent at the center of rotation. Slight additional pressure is normally required to move this knob off of the "0" setting. If any damage to the converter has occurred in shipment, notify the transportation company immediately.

2.2 LOCATION

This converter is designed for table top mounting. Four plastic feet on the underside raise the unit above the table surface and allow air to circulate under and upwards through the perforated covers. The converter may be mounted on a shelf or on top of other equipment; however, it should not be placed directly over sources of high heat, and space must be allowed for proper air circulation.

When rack mounting is desired, Option #1 (see figure 3) should be specified. This adapter extends

each side of the front panel frame an additional inch and contains mounting holes to accommodate a standard 19 inch rack. It also contains functional handles which assist in inserting the cabinet into the rack. When specified, Option #1 is installed at the factory; however, this adapter may be installed in the field as follows:

1. Remove top and bottom covers.
2. Remove the extrusion that forms the top of the front panel frame by removing the four Phillips head screws holding it in place.
3. Turn the cabinet on its side and from the inside carefully remove the two Phillips head screws which hold the front frame side to the inside of the cabinet. To gain access to the lower screw, slide the front panel upward slightly to allow screwdriver clearance. After removing these screws, slide the frame side out the open end. Replace this part of the frame with the rack mounting adapter and reinstall the two screws as before.
4. After completing step 3, turn the cabinet on its other side and repeat the same procedure.
5. After replacing both frame sides with the rack mounting adapters, reinstall the top extrusion which was removed in step 2.
6. The plastic mounting feet on the bottom cover may be removed and the covers reinstalled.

2.3 EXTERNAL CONNECTIONS

The following connections are available on the rear panel of the series 400 equipment:

2.3.1 Audio Input - *Speaker CX11A*

600 ohm unbalanced input is provided through a standard phono jack. Impedance matching is not critical as long as average voltage levels of approximately .5 volts rms are available. Although the converter will operate with only 10 mv. of input signal, the higher voltage levels are required to fully utilize the large dynamic range of this equipment.

When 600 ohm balanced input (Option #3) is required, the phono jack is replaced with a two terminal barrier strip and an input transformer is installed within the converter. Although the input winding of this transformer is floating, the center tap is available and may be grounded internally if required.

2.3.2 AFSK jack

The AFSK (Audio Frequency Shift Keyer) jack is connected in parallel with the Audio Input. The output of an external tone keyer such as the Electrocom TK-100 may be connected to this jack in order to monitor the tones on the CRT in the 400 during transmission. It is usually used only with transceivers, since they must mute the receiver section while transmitting. If an independent receiver is used in an RTTY installation, the receiver is usually left operative at all times and the "off the air" signal is monitored. Do not connect an external tone keyer to this jack when monitoring "off the air."

When a modulator (AFSK) card is installed in the 400, this AFSK jack is removed from the Audio Input and connected to the tone output of this card. If desired, the tones from the modulator card may be monitored by connecting a 3.3K ohm resistor between the AFSK and the Audio Input jacks.

2.3.3 Key

This jack is installed when using the Modulator Card. A telegraph key may be connected to it to allow CW keying of the tone.

2.3.4 Teletypewriter connections

Terminals 1 and 2 on the eight terminal barrier strip, J6, provide a keyed current loop for the teleprinter. The 130 volt loop supply is designed to circulate a maximum of 60 ma. through 1500 ohms, or 20 ma. through 5000 ohms. Several machines may be connected in series for simultaneous operation. When more than two selector magnets are placed in the loop circuit, it is desirable to shunt each with a transient suppression network. Such a network may be obtained from the printer manufacturer or constructed by using a 470 ohm, 1/2 watt resistor and a .1 mfd. 400 v. capacitor in series. When using neutral keying, terminal 2 is positive with respect to terminal 1 and is at ground potential. For receiving only, the selector magnet of the teleprinter should be connected between these terminals. When half-duplex transmission and reception is desired, connect the printer and keyboard in series between J6-1 and J6-2.

The series 400 converters contain a unique constant current loop power supply that may be set to any current from 20 thru 60 ma. Once set, this current will remain constant regardless of loop resistance or line voltage variations. Therefore, it is not necessary to meter the loop current to assure proper magnet drive. Machines or various loops may be switched at random without requiring manual readjustment of the loop current. Naturally, all machines in the loop must be designed to operate on the same current for which the loop has been set. When a low resistance loop circuit is used, internal heating may be reduced by placing a 1000 ohm, 25 watt resistor in series with the TTY circuit. Mount this resistor external to the converter in a non-confined area.

When polar current keying of the teleprinter is required, Options #4 or #5 may be installed on the Power/Keyer Card, p.n. 400-400. With these options the teleprinter still connects to terminals J6-1 and J6-2. However, both terminals will be above ground potential and terminal 1 will be positive with respect to terminal 2 for a marking condition. A spacing condition will reverse the current so that terminal 2 is positive with respect to terminal 1.

2.3.5 FSK Keying Voltage, EIA or MIL voltage levels

Voltage output is available on J6-3 which is suitable for feeding a transmitting keyer. This output may also be used to interface printers or other equipment requiring EIA RS232C voltage levels (-14 v. mark, +14 v. space) or MIL-STD-188C levels (+6 v. mark, -6 v. space). The grounded return for these voltages is J6-4. Keying information is obtained from the incoming signal when the converter is in the "Receive" state, or from the teleprinter loop when in the "Standby" state. If TTY equipment is not connected to J6-1 & J6-2, set the loop current to 20 ma., and connect these terminals together.

This output is normally wired for RS232C voltage levels. In order to change to MIL requirements the following modifications are required on the Power/Keyer Card, p. n. 400-400. Remove the connection between terminals R & S and M & N, by carefully cutting away the track on the PC board. Using jumper wires, connect R to N and M to S. This modification will reverse the polarity of the voltage output so that a marking condition will provide a positive voltage. Install resistor R15 on the card (2.4K ohm) to obtain ± 6 v. output. Other output voltages may also be obtained ranging between 0 and 14 volts by varying the value of R15. If the output voltage produced by a steady space tone is to be measured, antispace action must be disabled by turning S201 off.

2.3.6 Send Control (CTRL)

The power switch contains a "Send" position. When placed in this position, J6-5 is grounded to J6-4. This terminal may be connected to the push to talk (PTT) line of the transmitter or to other control circuitry as required.

*J6 (1A) -
(J4 E0) ?*

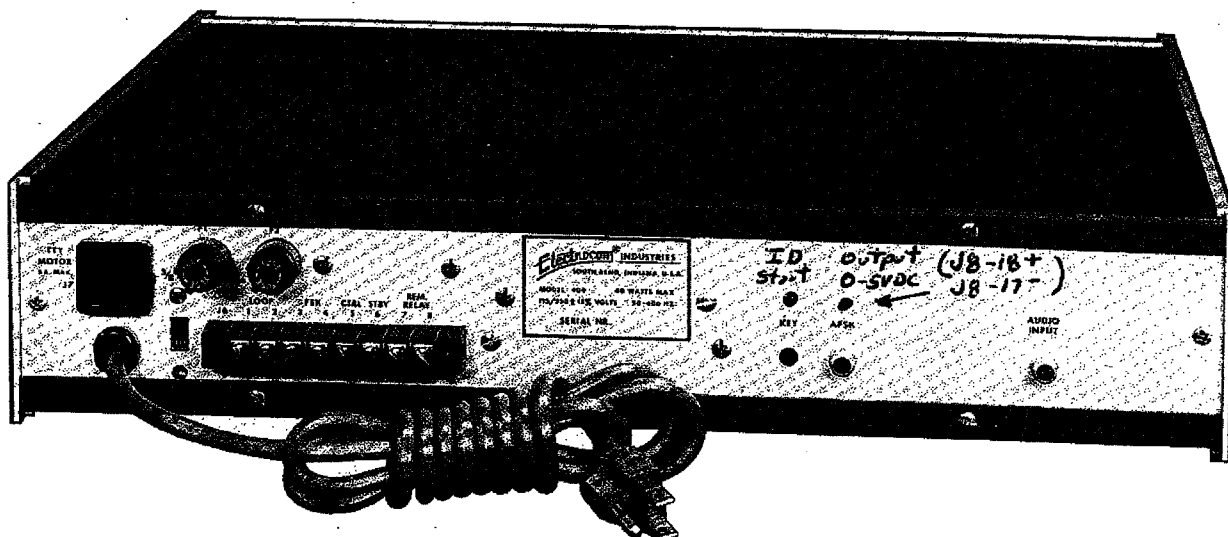


FIGURE 4, REAR VIEW OF MODEL 400 CONVERTER

2.3.7 Remote Standby (STBY)

All keying circuits of the 400 are placed in a "standby" (steady marking) condition regardless of the input signal by connecting J6-6 to ground (J6-4). When operating in the "Autostart" mode, the TTY motor will also be turned on. This standby connection is used primarily to prevent an incoming signal from keying the loop supply during local transmission. The loop is then keyed only by the TTY keyboard and the resulting keyed information is available as a voltage (terminal J6-3) for operating a keyer, and as keyed current into the printer for local monitoring. The logic circuitry within the 400 is designed to light both the "RECV" and "STBY" lamps simultaneously to alert the operator when the remote standby connection is grounded. If J6-6 is grounded by a transmitter control switch or relay contact, these lamps will indicate that the system is transmitting RTTY.

2.3.8 REM. RELAY

Terminals J6-7 and J6-8(+) provide 20 VDC to energize a remote motor control relay. The total relay current drawn should not exceed 50 ma. Since the control input of the Electrocom p.n. 454206 solid-state relay draws only 6 ma., several may be connected in parallel to control individual teleprinter motors some distance from the converter. The contacts on each of these relays should be wired in series with a TTY power switch. One of these relays is contained within the 400 converter and may be used to control the motor of a machine adjacent to the converter, as described below.

2.3.9 TTY MOTOR Receptacle

A controlled 3 wire AC receptacle (J7) is provided for operation of the teletypewriter motor. This receptacle is controlled by the internal solid-state relay and conveniently allows autostart operation of a nearby machine. The operating voltage supplied to this receptacle is the same as that applied to the

converter. Therefore, if the 400 is operated from a higher voltage than required for the teletype machine, the proper step-down transformer must be installed between this receptacle and the motor. The internal relay, Electrocom p.n. 454206 is a solid-state optically isolated unit rated for operation between 90 and 240 volts at a maximum of 5 amperes. It will operate from 50 to 400 Hz. power; however, if the equipment will be operated from *only* 400 Hz., this relay may be replaced with Electrocom p.n. 454246 which will have less "off" leakage current.

In order for J7 to control the TTY machine, the TTY power switch must be left in the "ON" position. Some machines contain a "line shunt relay" which has contacts that shunt the selector magnet coil, thereby removing the current from this magnet, whenever the motor is turned off. As a result, the machine will clatter while the motor is coasting to a stop. These contacts should be disconnected so that the loop circuit is continuous through the selector at all times. The control circuitry of the 400 will then maintain loop current on the selector until after the motor has quietly stopped. Shortly afterwards, the loop current will turn off and place the machine in a complete standby condition.

2.3.10 Power Cordset

A three wire grounded power cord provides all power to the 400. The round pin connects to the chassis through the green wire in the cord. If the AC outlet to which this cord is connected does not have a grounded receptacle, use a cable adapter and ground the green wire of this adapter. A slide switch adjacent to the power cord allows the selection of 115 or 230 volt operation. Fuse F1 protects this equipment for 115 volt operation while F2 provides 230 volt protection. Therefore, it is not necessary to change fuses when switching voltages. **Be certain that the voltage range switch is in the proper position before applying power to this equipment.**

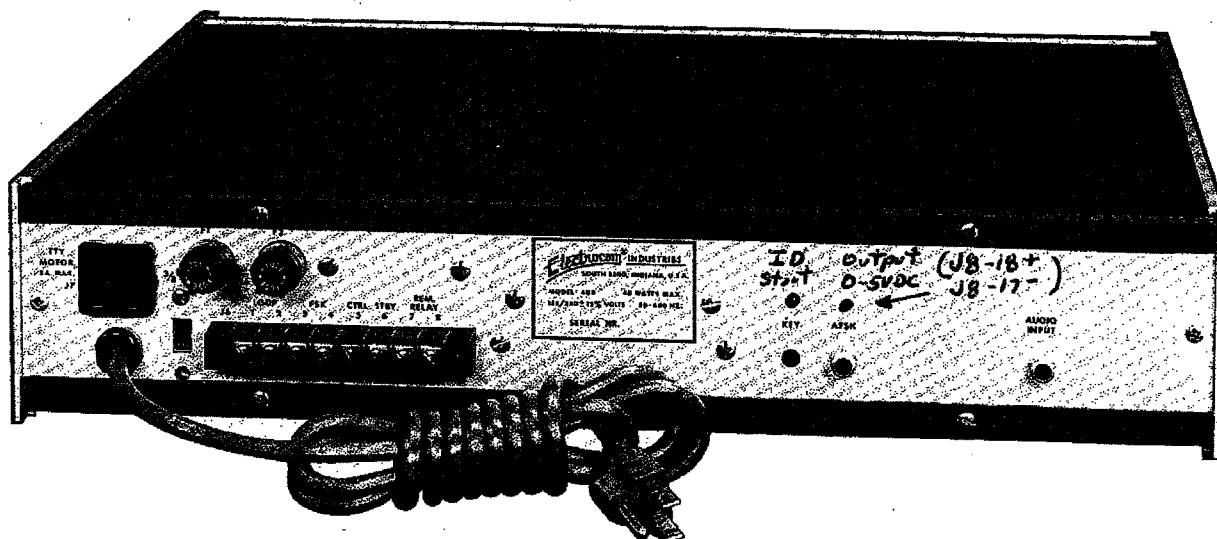


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In order for J7 to control the TTY machine, the TTY power switch must be left in the "ON" position. Some machines contain a "line shunt relay" which has contacts that shunt the selector magnet coil, thereby removing the current from this magnet, whenever the motor is turned off. As a result, the machine will clatter while the motor is coasting to a stop. These contacts should be disconnected so that the loop circuit is continuous through the selector at all times. The control circuitry of the 400 will then maintain loop current on the selector until after the motor has quietly stopped. Shortly afterwards, the loop current will turn off and place the machine in a complete standby condition.

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A three wire grounded power cord provides all power to the 400. The round pin connects to the chassis through the green wire in the cord. If the AC outlet to which this cord is connected does not have a grounded receptacle, use a cable adapter and ground the green wire of this adapter. A slide switch adjacent to the power cord allows the selection of 115 or 230 volt operation. Fuse F1 protects this equipment for 115 volt operation while F2 provides 230 volt protection. Therefore, it is not necessary to change fuses when switching voltages. **Be certain that the voltage range switch is in the proper position before applying power to this equipment.**

SECTION 3, OPERATION

3.1 FRONT PANEL CONTROLS, MODEL 400

The Model 400 front panel controls function as follows:

3.1.1 CHANNEL

Position "1" — Provides a choice of one fixed set of tones preset internally. (See paragraph 3.3.4.) Any tones in the range from 1000 to 3200 Hz. may be set for both the mark and space frequencies. Provides reception on both mark and space frequencies in combination or independently.

Position "1M" — Provides operation on the mark signal only of Channel 1. Space signal is disabled.

Position "1S" — Provides operation on the space signal only of Channel 1. Mark signal is disabled.

Position "2" — Provides a choice of a fixed mark frequency (may be adjusted internally) and a variable space frequency which is adjusted by the front panel SHIFT control. Provides operation on both mark and space frequencies in combination or independently.

Position "2M" — Provides operation on the mark signal only of Channel 2. Space signal is disabled.

Position "2S" — Provides operation on the space signal only of Channel 2. Mark signal is disabled.

NOTE: In positions 1M, 1S, 2M, and 2S all auto-start and markhold features are disabled. Although the Keying selector may be placed in the AUTO or MARK positions, the TTY motor will be turned on and performance will be the same as for the NORMAL position.

3.1.2 SHIFT

This control varies the space frequency when the "Channel" selector is in the "2, 2M, or 2S" positions. If the switch located directly above the shift control is in the "LOW" position, the space frequency may be varied from 0 to 1000 Hz. below the mark frequency. If in the "HIGH" position, the space frequency may be varied from 0 to 1000 Hz. above the mark frequency. Frequency shift is the difference between the mark and space frequencies, and is accurately displayed on the digital knob which is calibrated in Hertz.

3.1.3 BAUD

This switch sets the low pass filter time constants for optimum operation on various teleprinter speeds from 45 to 75 bauds (60 to 100 wpm for 5 level Baudot code). During continuous tape speed sending with reasonable signal conditions, best overall performance will be obtained by setting this switch to correspond with the baud rate being re-

ceived. However, with slow periodic sending under poor conditions, quite often the overall error rate can be reduced by changing the baud rate setting. For this reason, a 40 baud position is included which will allow lowering the filter cutoff, although 40 bauds is below the standard teleprinter speeds. The response of this filter may also be raised above the optimum cutoff for a given speed by selecting a higher baud rate than is being received.

3.1.4 KEYING

This switch programs the overall operation of the converter system as follows:

3.1.4.1 — NORMAL

Provides normal operation of the converter without any mark-hold or automatic motor control operation. This position will allow copy of marginal signals which are into the noise level and are below the threshold required for operation in the MARK or AUTO positions.

3.1.4.2 — STANDBY

Places the loop current keyer in a steady marking condition regardless of the input signal.

3.1.4.3 — REVERSE

Provides the same operation as in the "Normal" position, except that the sense of frequency shift is reversed. When moving from the "Normal" to "Reverse" positions, or vice versa, pause momentarily in the "Standby" position. This delay will place the machine in a marking condition and allow it to synchronize quicker when keyed information is again applied.

3.1.4.4 — MARK

The teletypewriter operates the same as in the "Normal" position with the addition of "Mark-hold" circuitry. In the event of signal loss for more than about one second, the mark-hold circuitry places the printer in a steady marking condition until an acceptable signal is present for one second. An acceptable signal must be either a steady mark, or a keyed signal having teleprinter code characteristics. The time constants of this circuit assure that the longest character of a 60 wpm signal will be accepted, but reject long space durations which are not characteristic of teletype signals.

3.1.4.5 — AUTO

In all of the above operational modes the motor of a teletypewriter, controlled from either receptacle J7 or from a remote relay, will be turned on whenever the 400 power switch is on. In this "Autostart" position, however, the motor is controlled by the

logic circuits within the converter. The motor will remain off until an acceptable signal (see paragraph 3.1.4.4) is present for approximately three seconds. The motor will then turn on and the system will operate as described for MARK except that the mark-hold action will occur after 3 seconds of signal loss. If an acceptable signal is not received within approximately 50 seconds after the printer goes into mark-hold, the motor will automatically turn off. About 7 seconds later, the loop current will turn off and the system will be in a complete stand-by condition with minimum power drain. As soon as an acceptable signal is again present for 3 seconds, the motor and loop current will turn on and the complete cycle will repeat.

If this Keying switch is in the AUTO position when power is first applied, the motor will turn on. Unless a signal is present, the motor will turn off in 50 seconds and await an autostart command.

3.1.5 BIAS

This variable control allows corrective bias to be inserted into the keying circuitry for compensation of incorrectly biased incoming signals. When in the vertical ("0") position this control snaps into a detent to firmly establish a "zero bias" setting for receiving properly biased signals. If teleprinter copy is marginal, particularly during reasonable signal conditions, this control should be adjusted over its range to determine if improved printing is obtainable. When the knob is turned towards the M, marking bias is inserted in order to correct a spacing biased incoming signal. Turning the knob towards S inserts spacing bias for correcting an incoming signal with marking bias distortion.

3.1.6 POWER

Power to all converter circuits is controlled from this switch. The teleprinter motor is also operated when plugged into the TTY Motor receptacle, J7, or controlled by a remote relay connected to J6-7 and J6-8. The positions function as follows:

3.1.6.1 — OFF

Power to the converter and teletypewriter is turned off.

3.1.6.2 — ON

Power is turned on to all circuits except the CRT monitor and its associated High Voltage power supply. The motor of the TTY will be controlled in accordance with the Keying selector switch. When the 400 is used for unattended operation, the power switch should be left in this position and the keying switch placed in the AUTO position. Input power will be reduced to less than 10 watts when the motor turns off.

3.1.6.3 — CRT

Power is turned on to all circuits including the Cathode Ray Tube monitor. This position is used for normal operator attended operation.

CAUTION: 1000 volts DC appears on the Monitor Card, CRT connector, and intensity sensor (PE1). If the covers are removed, use extreme caution and prevent contact with these items when CRT power is on.

3.1.6.4 — SEND

Monitor (CRT) high voltage is turned off, CRT filament is left on, and the transmitter control contacts are closed. If a Modulator Card is not installed in the 400, the CRT may be left operative in this position by connecting a jumper wire between J4-X and J4-W on the Power/Keyer Card connector. When a Modulator Card (tone keyer) is installed in the 400, this position turns the tone keyer on. CRT operation is then controlled by a connection on the Modulator Card.

3.2 FRONT PANEL CONTROLS, MODEL 402

3.2.1 CHANNEL

Positions "1, 1M, and 1S" on the Model 402 function exactly as on the Model 400. Refer to paragraph 3.1.1. Positions "2, 2M, and 2S" function as follows:

Position "2" — Provides a choice of both the mark and space frequencies from front panel mounted digital knobs which are both continuously variable over the range from 1000 to 3000 Hz. Provides reception on both mark and space frequencies in combination or independently.

Position "2M" — Provides operation on the mark signal only of Channel 2. Space signal is disabled.

Position "2S" — Provides operation on the space signal only of Channel 2. Mark signal is disabled.

3.2.2 SPACE FREQ.

A 10 turn digital knob determines the space tone frequency which will be received by the Model 402, for "Channel 2" positions. The "1K, 2K" range switch mounted directly above this knob selects the lowest frequency setting. When in the "1K" position, the space frequency obtained is 1000 Hz. plus the digital knob reading. Thus, for a knob reading of "275" and a range setting of "1K" the space frequency is $1000 + 275 = 1275$ Hz. A knob setting of "275" and a range setting of "2K" provides a space frequency of $2000 + 275 = 2275$ Hz.

3.2.3 MARK FREQ.

This 10 turn digital knob and associated range switch sets the Model 402 mark tone frequency for

Operation

"Channel 2" positions in exactly the same manner as the space frequency controls described in paragraph 3.2.2.

3.2.4 KEYING, BAUD & POWER Switches

These switches operate exactly as those on the Model 400. Refer to paragraphs 3.1.4 (Keying), 3.1.3 (Baud), and 3.1.6 (Power).

3.2.5 Bias Adjustment

The front panel Bias control has been omitted from the Model 402. An internal bias adjustment is contained on the Logic Card, p.n. 400-200. This adjustment is normally set for "0" bias during calibration procedures. If a particular transmission path consistently contains biased signal information, this adjustment may be set to provide the proper bias correction as described in the "Test and Calibration" procedures in this manual. Otherwise, this adjustment should be left in the zero bias setting in order to best accommodate proper, unbiased incoming signals.

3.3 INTERNAL CONTROLS

The controls described in this section do not normally require adjustment after the initial setting. They are the only controls which may be adjusted without following complete test and calibration procedures. Access is obtained by removing the top cover. The locations described are viewed from the front of the unit. They are shown in figures 10, 12 and 13.

3.3.1 LOOP CURRENT ADJUSTMENT

Located in the center and towards the rear on Power/Keyer Card, p.n. 400-400, is the LOOP ADJ control (marked R5 on the PCB). This variable resistor will allow the loop current to be set to any value from 20 through 60 ma. Unless otherwise noted on the converter, the loop current has been factory adjusted for 20 ma.

Adjustment is as follows: With the Power switch turned OFF, remove the TTY machine and connect a milliammeter between terminals J6-1 and J6-2 (+). Place the Keying selector switch in STANDBY, and turn the Power switch to the ON position. **CAUTION** — The fuseholders and AC power connections are located directly behind the loop adjustment resistor. Be careful to avoid contact with these since power line voltage is present. Using an insulated shaft screwdriver or alignment tool, adjust the LOOP ADJ control until the proper current is indicated on the meter. Turn off the power, remove the meter, and reconnect the TTY machine. The current which has been set will remain constant regardless of loop resistance or line voltage variations over the specified operating range of the 400. (*Note: The meter may be connected in series with the teletypewriter and one of these terminals, if preferred.)

3.3.2 POLAR CURRENT ADJUSTMENT

When the Power/Keyer Card, p.n. 400-400, is equipped with polar keying options #4 or #5, a POLAR ADJ control (marked R18 on the PCB) is located to the right of the LOOP ADJ control. A similar procedure to that described in paragraph 3.3.1 is used, except the milliammeter must be placed in series with the teletypewriter connection between terminals J6-1 and J6-2. Use either a zero center meter or a reversing switch on the meter so that the positive terminal connects to J6-1 for a marking condition. Adjust the mark current using the LOOP ADJ control as described in paragraph 3.3.1.

To set the spacing polar current either of two methods may be used:

(Method 1) On the Power/Keyer Card, connect a test lead from the end of R16 closest to R5 (LOOP ADJ) to ground. (Ground may be most conveniently obtained from either the green wire connected to the rear of the AC receptacle, or from the ground test pin on the Demodulator Card.) Adjust the spacing loop current using the POLAR ADJ control. The current will be reversed such that terminal J6-2 will be positive. After adjustment, remove the test lead.

(Method 2) Connect a space tone to the audio input of the converter and place the Keying switch in the NORMAL position. Disable the anti-space circuitry as described in paragraph 3.4. This will allow the incoming signal to maintain a constant spacing current. Adjust POLAR ADJ (R18) to obtain the proper value. Return the anti-space switch, S201, to the "on" position.

Once these adjustments are completed, the meter may be removed from the circuit and the teletypewriter connected directly to J6-1 (+) and J6-2. If the machine does not remain marking when the keying selector is in the standby position, reverse the connections to J6-1 & J6-2.

3.3.3 CRT CONTROLS

These controls adjust the front panel CRT Monitor display. If adjustment is required, place the Power switch in the CRT position and feed the proper mark and space tones into the audio input of the 400. Use an insulated screwdriver to adjust the controls and avoid contact with the Monitor Card and its components, since a maximum of 1000 volts exists on this card.

A convenient source of input signal may be obtained by using a communications receiver having calibration and beat frequency oscillators. With both of these oscillators turned on, adjust the receiver's tuning dial near a calibration frequency so as to produce the required tone frequency.

3.3.3.1 Located near the center of the forward edge of the Monitor Card, p.n. 400-300, are the Horizontal (R11) and Vertical (R8) positioning controls. These allow centering of the CRT display on the face of the screen. Rotating the HORIZ POS control clockwise moves the pattern to the right,

"Channel 2" positions in exactly the same manner as the space frequency controls described in paragraph 3.2.2.

3.2.4 KEYING, BAUD & POWER Switches

These switches operate exactly as those on the Model 400. Refer to paragraphs 3.1.4 (Keying), 3.1.3 (Baud), and 3.1.6 (Power).

3.2.5 Bias Adjustment

The front panel Bias control has been omitted from the Model 402. An internal bias adjustment is contained on the Logic Card, p.n. 400-200. This adjustment is normally set for "0" bias during calibration procedures. If a particular transmission path consistently contains biased signal information, this adjustment may be set to provide the proper bias correction as described in the "Test and Calibration" procedures in this manual. Otherwise, this adjustment should be left in the zero bias setting in order to best accommodate proper, unbiased incoming signals.

3.3 INTERNAL CONTROLS

The controls described in this section do not normally require adjustment after the initial setting. They are the only controls which may be adjusted without following complete test and calibration procedures. Access is obtained by removing the top cover. The locations described are viewed from the front of the unit. They are shown in figures 10, 12 and 13.

3.3.1 LOOP CURRENT ADJUSTMENT

Located in the center and towards the rear on Power/Keyer Card, p.n. 400-400, is the LOOP ADJ control (marked R5 on the PCB). This variable resistor will allow the loop current to be set to any value from 20 through 60 ma. Unless otherwise noted on the converter, the loop current has been factory adjusted for 20 ma.

Adjustment is as follows: With the Power switch turned OFF, remove the TTY machine and connect a milliammeter between terminals J6-1 and J6-2 (+). Place the Keying selector switch in STANDBY, and turn the Power switch to the ON position. **CAUTION** — The fuseholders and AC power connections are located directly behind the loop adjustment resistor. Be careful to avoid contact with these since power line voltage is present. Using an insulated shaft screwdriver or alignment tool, adjust the LOOP ADJ control until the proper current is indicated on the meter. Turn off the power, remove the meter, and reconnect the TTY machine. The current which has been set will remain constant regardless of loop resistance or line voltage variations over the specified operating range of the 400. (*Note: The meter may be connected in series with the teletypewriter and one of these terminals, if preferred.)

3.3.2 POLAR CURRENT ADJUSTMENT

When the Power/Keyer Card, p.n. 400-400, is equipped with polar keying options #4 or #5, a POLAR ADJ control (marked R18 on the PCB) is located to the right of the LOOP ADJ control. A similar procedure to that described in paragraph 3.3.1 is used, except the milliammeter must be placed in series with the teletypewriter connection between terminals J6-1 and J6-2. Use either a zero center meter or a reversing switch on the meter so that the positive terminal connects to J6-1 for a marking condition. Adjust the mark current using the LOOP ADJ control as described in paragraph 3.3.1.

To set the spacing polar current either of two methods may be used:

(Method 1) On the Power/Keyer Card, connect a test lead from the end of R16 closest to R5 (LOOP ADJ) to ground. (Ground may be most conveniently obtained from either the green wire connected to the rear of the AC receptacle, or from the ground test pin on the Demodulator Card.) Adjust the spacing loop current using the POLAR ADJ control. The current will be reversed such that terminal J6-2 will be positive. After adjustment, remove the test lead.

(Method 2) Connect a space tone to the audio input of the converter and place the Keying switch in the NORMAL position. Disable the anti-space circuitry as described in paragraph 3.4. This will allow the incoming signal to maintain a constant spacing current. Adjust POLAR ADJ (R18) to obtain the proper value. Return the anti-space switch, S201, to the "on" position.

Once these adjustments are completed, the meter may be removed from the circuit and the teletypewriter connected directly to J6-1 (+) and J6-2. If the machine does not remain marking when the keying selector is in the standby position, reverse the connections to J6-1 & J6-2.

3.3.3 CRT CONTROLS

These controls adjust the front panel CRT Monitor display. If adjustment is required, place the Power switch in the CRT position and feed the proper mark and space tones into the audio input of the 400. Use an insulated screwdriver to adjust the controls and avoid contact with the Monitor Card and its components, since a maximum of 1000 volts exists on this card.

A convenient source of input signal may be obtained by using a communications receiver having calibration and beat frequency oscillators. With both of these oscillators turned on, adjust the receiver's tuning dial near a calibration frequency so as to produce the required tone frequency.

3.3.3.1 Located near the center of the forward edge of the Monitor Card, p.n. 400-300, are the Horizontal (R11) and Vertical (R8) positioning controls. These allow centering of the CRT display on the face of the screen. Rotating the HORIZ POS control clockwise moves the pattern to the right,

while clockwise movement of the VERT POS control moves the pattern upwards. Centering is accomplished by alternately feeding mark and space tones into the 400 and positioning the display with these controls.

3.3.3.2. The minimum intensity consistent with good visibility will improve viewing and reduce the screen burning effect on the CR tube, thereby extending its life. Since greater intensity is required to see the monitor trace in a brightly lit area than in darkness, automatic intensity control circuitry has been incorporated into the 400. A photocell senses the amount of light present on the face of the CRT and automatically adjusts trace brightness in proper contrast to ambient light. This sensor is encased in the lower right hand corner of the monitor bezel, and plugs into a socket underneath. If during maintenance the bezel is removed, take care to avoid physical contact when CRT power is on, since 800 volts then exists between this photocell and the cabinet.

On the right side of the monitor card are the INTENSITY (R30) and FOCUS (R26) controls. To assure satisfactory CRT brightness for all lighting levels, adjust R30 in darkness or under dim lighting to provide the minimum trace brightness consistent with good visibility. After setting the INTENSITY control, return to normal lighting and adjust the FOCUS control to obtain the sharpest vertical and horizontal traces.

3.3.3.3 The Horizontal (R17) and Vertical (R1) Gain controls adjust the size of the CRT display. With the Channel selector switch in the "2M" position and the input signal frequency adjusted to provide the maximum length vertical trace, adjust the VERT GAIN control for a trace length of about 34 mm. Next, place the Channel selector in the "2S" position, set the input frequency to provide a maximum length horizontal trace, and adjust this trace length to about 34 mm. with the HORIZ GAIN control.

3.3.4 CHANNEL #1 FREQUENCY ADJUSTMENTS

The tone frequencies selected in the "1, 1M, and 1S" positions of the Channel selector switch are preset internally by adjusting 25 turn trimmer potentiometers. These are located near the front end of the Demodulator Card p.n. 400-100. The mark and space frequencies are adjusted with the M-1 (R19) and S-1 (R34) trimmers respectively. Turning these controls in a clockwise direction increases the frequency. Either control may be adjusted to accept tones anywhere in the range from 1000 to 3200 Hz. The mark and space tones should be adjusted no less than 75 Hz. apart.

To set the mark tone, place the channel selector in the "1M" position, the Power switch to CRT, and feed a mark tone of the proper frequency into the audio input. Adjust the M-1 control until the maximum length vertical line appears on the CRT display. Set the space tone by moving the Channel

selector to the "1S" position, feed the proper space tone into the 400, and adjust the S-1 control until the maximum length horizontal line is obtained. *Be careful when making these adjustments not to disturb the settings of the controls adjacent to M-1 and S-1.* Should they be changed, complete calibration procedures will be required in order to assure proper frequency calibration for Channel 2.

If the frequency of the incoming tone is questionable, the calibrated "Shift" knob on the Model 400 may be used for measurement. For tones between 2125 and 3125 Hz., select the "High" range, subtract 2125 Hz. from the desired frequency, and set the shift control to this difference. For tones between 1125 and 2125 Hz., select the "Low" range, subtract the desired frequency from 2125 Hz., and set the shift control accordingly. Place the channel selector in the "2S" position and vary the input frequency until the maximum length horizontal trace is produced. Then return the channel selector to the "1S or 1M" positions and set the Channel 1 adjustments as described above. In a similar manner, the Model 402 may be used for measurement by calibrating the incoming frequency directly against the Channel 2 space frequency knob reading.

3.4 ANTI-SPACE CIRCUIT

Circuitry is contained on the Logic Card, p.n. 400-200, which limits the duration of the space pulse that the 400 keying circuit will accept. The time constant of this circuit is normally set to approximately 142 msec., which will allow the longest character of a 60 wpm, 45.45 baud signal to be received. If the length of a space pulse exceeds this amount, the keying circuit immediately reverts to a marking condition until another incoming mark pulse is received. This mark pulse resets the circuit so that it will again respond to incoming signals. If the 400 is used *only* for higher speed operation, the acceptable space duration may be reduced. In any event, this time constant should be adjusted to accept the lowest baud rate required. Adjustment of the anti-space time constant is described in section 5.5.2.4.

Synchronization of the teleprinter occurs upon receipt of the start pulse which is a transition from a marking to a spacing condition. Since the anti-space circuit promptly returns the TTY to a marking condition upon receipt of an invalid space signal, the machine is ready to re-synchronize as soon as another start pulse is received. As a result, this anti-space action will often reduce the amount of erroneous characters printed during signal losses.

The anti-space circuit will also keep the TTY from misprinting in the event that the "Break" key is depressed, or the TTY loop is placed in a spacing condition for CW keying or other purposes. Since the longest character is the "Blank" function which is a non-printing condition on the teleprinter, the receipt of a space for longer than 142 msec. converts the signal into a "blank" character and there is no misprinting.

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If the system with which the 400 is used operates at lower speeds than 45 bauds, or if the system requires the acceptance of a continuous space signal, the anti-space circuit is easily disabled by the "Antispace" switch, S201, which is located on the Logic Card, p.n. 400-200. Access is gained by removing the bottom cover of the 400. Place this slide switch in the OFF position to completely disable anti-space operation.

Should some systems require that the anti-space feature be changed frequently, a remote anti-space switch may be mounted on the front panel or other convenient location. Circuit modifications for adding this remote switch are shown as Δ on the Logic Card schematic diagram, drawing number 400201.

3.5 FRONT PANEL INDICATORS

Two front panel LED lamps indicate "Standby" and "Receive" conditions of the converter. Any condition which will place the keying circuits in a non-printing mode (Standby, Anti-space, and Mark-hold) will light the red STBY indicator. When the circuits are in a printing condition the green RECV indicator will light. Both of these lamps will light simultaneously only if the remote standby terminal J6-6 is grounded, as described in paragraph 2.3.7.

3.6 CRT MONITOR AND TUNING INDICATOR

The Cathode Ray Tube monitor, located in the center of the front panel, provides an accurate and rapid means of adjusting a variable frequency communications receiver for proper reception of FSK signals. It will also indicate conditions of severe fading, noise, receiver or transmitter drift, and improper transmitter shift adjustment. When very little signal or noise is received within the mark or space channels, the CRT trace will be extinguished by an automatic blanking circuit after approximately one second. Immediately upon receipt of a signal the display will be visible. This feature helps to reduce burned spots on the center of the CRT screen.

The monitor circuitry in the series 400 equipment monitors the combined detector outputs to give an indication of the quality of signal that is producing the keying information. This detected voltage is used to control variable gain amplifiers (multipliers) which display the incoming signals, as processed by the limiter, with respect to the demodulated signal. This type of presentation gives an excellent indication of overall system performance, and provides sharp, straight lines regardless of the amount of shift.

When the receiver is properly tuned a vertical line will appear on the CRT during a mark signal and a horizontal line will appear during a space signal. The speed at which the signal is being shifted during transmission will cause these two lines to appear as a crossmark on the monitor screen. Proper tuning will give maximum amplitude to both lines simultaneously. With the Channel selector in the "1" or "2" positions, the maximum length of both

lines will be reduced as the separation between mark and space frequencies approaches the bandwidth of the filters. As the shift is reduced to "000," the display will approach a dot. This results from the overlapping skirt selectivities of the mark and space filters, and the discriminator action of the mark/space combiner. For shifts down to 75 Hz. the shift knob on the Model 400 should be set to the value of shift being received. The two knobs on the Model 402 should be set to the desired frequencies, while maintaining a separation of at least 75 Hz. To copy narrower shifts, set these knobs for 75 Hz. and stagger tune the incoming signal to produce equal length mark and space lines.

During periods of extreme fading or "dropout" the vertical or horizontal lines will disappear for an instant and then return. High noise on the signals will cause the lines to appear unstable and have ragged ends. If transmitter or receiver drift occurs, the size of the crossmark will be reduced. The receiver should then be retuned for maximum crossmark amplitude. Should the shift adjustment of a transmitter drift, one indicator line will remain at maximum length while the other one will be reduced. If this condition occurs while using the Model 400, tune the receiver to produce a full vertical line, and adjust the SHIFT control to produce the longest horizontal line. When using the Model 402, simply adjust the MARK and/or SPACE frequency knobs until the maximum crossmark is obtained on the CRT.

3.7 SHIFT MEASUREMENT

The excellent calibration accuracy resulting from highly stable, linear VCO circuitry, precision tuned and temperature compensated narrow bandwidth filters, and a 10 turn digital knob with 1 Hz. reading accuracy allows the series 400 equipment to be used for measuring frequency shift. Keep in mind, however, that the overall system accuracy is ± 12 Hz. of dial reading and that the peak of the filter response is several Hz. wide. Therefore, it is difficult to accurately determine the exact peak on the CRT display. If reasonable care is exercised shift measurements to within 10 Hz. are usually obtainable. From a practical system standpoint this is excellent accuracy, being within 0.5% at mid-range frequency. However, if extreme shift accuracy must be guaranteed, it is advisable that a frequency counter be used for this measurement.

3.7.1 When measuring the shift of an incoming signal on the Model 400: tune the receiver for the maximum length mark line, and then adjust the SHIFT control until the maximum length space line is obtained. If the signal is being keyed during this measurement, the size of the crossmark should diminish equally for both traces as the receiver is slowly tuned either side of the frequency. When measuring narrow shifts, it is often helpful to display only one tone at a time. This is achieved by placing the Channel selector in the "2M" or "2S" positions.

3.7.2 When measuring the shift of an incoming signal on the Model 402, first set the MARK FREQ to a convenient reading. Then tune the receiver until the maximum length mark line is presented on the CRT. The SPACE FREQ knob is next turned to produce the maximum length space line. The frequency shift is obtained from the difference of the two dial readings. Once again, the crossmark on a keyed signal should diminish equally as the receiver is tuned from the center frequency.

The Model 402 may also be used to measure tone frequencies or shifts of Audio FSK signals coming from a non-tuneable source. Set the MARK and SPACE frequency knobs to obtain the maximum length CRT traces and read the frequencies directly from each knob. Again, the shift is the difference of these two readings.

3.8 TRANSMITTER SHIFT ADJUSTMENT

The 400 equipment is equally useful for monitoring, checking, or setting the shift of a local FSK transmitter. The receiver is left operative during transmission and tuned to the transmitter frequency. The transmitted signal may then be monitored or the shift checked in the same manner as described in section 3.7. To set the shift of an adjustable FSK transmitter: (1) set the 400 to the desired amount of shift, (2) transmit the mark frequency, (3) adjust the receiver to produce the longest mark trace, (4) transmit the space frequency, and (5) set the transmitter shift adjustment to produce the maximum length space display.

CAUTION: If the 400 equipment is located in areas of high RF energy, the field produced may be received by the detectors that control the CRT display. If this occurs, the peak indication on the CRT monitor may be in error. If the SWR on local transmitting equipment is kept within good engineering limits the CRT displays should not be affected. When high powered amplifiers are used, check the display while monitoring only the exciter and again with the amplifier operating, in order to determine if the increased RF energy will change the display.

3.9 RECEIVER TUNING

The reception of FSK signals in the high frequency spectrum is best accomplished with a tuneable communications receiver having excellent stability, a product detector with variable bfo, selectable bandwidth — steep skirted I F filters, and a signal strength ("S") meter. Practically all receivers designed for SSB reception meet these requirements. Older types of receivers which use a diode detector and bfo are also usable provided they can maintain the required stability. The series 400 equipment contains optimum narrow bandwidth filters, and the receiver must be able to maintain ± 40 Hz. stability to avoid frequent retuning. The following procedure will assure the best reception of an FSK signal:

3.9.1 If the receiver has variable selectivity, select a bandwidth at least 1.6 times greater than the amount of shift being received. With the "S" meter and AVC operating, adjust the tuning dial on the receiver until the S meter shows little or no variation as the incoming FSK signal is shifting from mark to space. This adjustment will assure equal receiver sensitivity for both frequencies.

3.9.2 Turn the product detector and/or variable bfo on. (CW or SSB operation.)

Paragraphs 3.9.3 through 3.9.6 apply only when using the Model 402, or the Model 400 with receivers having a variable bfo and audio response to 3000 Hz.

3.9.3 When using the Model 400, place the range switch in the HIGH position and set the SHIFT control for the amount of shift to be received.

3.9.4 When using the Model 402, set the mark and space channel frequencies to accept the shift of the received signal. Any tone frequencies may be used as long as they are within the range of the receiver's bfo and audio system. Normally, the mark frequency will be the lower tone and the space frequency will be higher by the amount of shift required.

3.9.5 For receivers not having passband tuning, adjust the bfo pitch control until a crossmark appears on the face of the monitor. The pitch control is normally adjusted so as to place the bfo on the high frequency side of the received signal. This setting will generate a mark tone lower than the space tone (normal sensing of shift) when the transmitted mark carrier frequency is the higher radio frequency. Under these conditions the Model 400 mark tone will be 2125 Hz. and the space tone will be higher by the amount of shift. If the crossmark does not reach full amplitude on both frequencies simultaneously, use Channel 2 on the 400, and adjust the bfo for the longest vertical line and the SHIFT control for the longest horizontal line. Once the correct position of the bfo is determined, all future tuning is done with the main tuning dial only.

3.9.6 Selectable sideband receivers having "passband tuning" should be operated in the lower sideband position and the passband control centered midway between the mark and space tone frequencies. For example: When receiving 850 Hz. shift using tones of 2125 and 2975 Hz. center the passband tuning at 2550 Hz. The crossmark is then obtained by adjusting the main tuning dial of the receiver.

3.9.7 When receiving under the conditions given above, the horizontal line may not appear if the shift setting is in error by more than 125 Hz. The following procedure will enable the operator to quickly determine if the shift setting is too narrow or too wide. After peaking the mark signal, re-tune the receiver dial until the space signal appears on the horizontal trace. If the receiver dial was tuned higher in frequency, the shift is narrower than the setting on the 400. Tune the receiver back to the

Operation

mark maximum vertical trace and reduce the SHIFT setting on the 400 until the proper crossmark occurs. If the receiver had to be tuned lower in frequency, the shift was wider than the 400 setting, and the SHIFT control will have to be increased.

Paragraphs 3.9.8 and 3.9.9 apply to the Model 400 when used with transceivers, or receivers not having a variable bfo or audio response above 2500 Hz.

3.9.8 Place the range switch of the Model 400 in the LOW position, and set the SHIFT control for the amount of shift to be received.

3.9.9 Operate the receiver in the Upper Sideband position in order to place the bfo below the received signal. This setting will generate a mark tone above the space tone when the transmitted mark carrier is the higher radio frequency (Normal sensing of shift). Under these conditions the mark tone will be 2125 Hz. and the space tone will be lower by the amount of shift. If the crossmark does not reach full amplitude on both frequencies simultaneously, use Channel 2 on the model 400, adjust the receiver tuning dial for the maximum vertical line, and the SHIFT control for the maximum hor-

izontal line. The horizontal line may not appear if the shift setting is in error by more than 125 Hz. Use the same procedure described in paragraph 3.9.7 to easily determine if the error is narrow or wide.

3.9.10 Once the receiver is tuned, adjust the audio gain control so that any further variation will not effect the size of the monitor display. It is recommended that the audio level into the 400 be set for an average value of at least .5 volts rms in order to utilize the large dynamic range of this equipment.

3.9.11 The AVC may be left operative and the RF gain control on the receiver left at maximum. If a choice of AVC action is available, experimentally determine the best setting for existing propagation conditions.

3.10 DIVERSITY OPERATION

Two or more 400 converters may be easily connected together for diversity reception by joining the summing junctions of the channel detectors. (Available at J1-K, J1-9, or S2-1.) Consult the factory for complete modification details.

SECTION 4, THEORY OF OPERATION

4.1 OVERALL SYSTEM OPERATION

The overall operation of the Series "400" Frequency Shift Converters is most easily understood by referring to the simplified block diagram, figure 5.

4.1.1 Demodulation

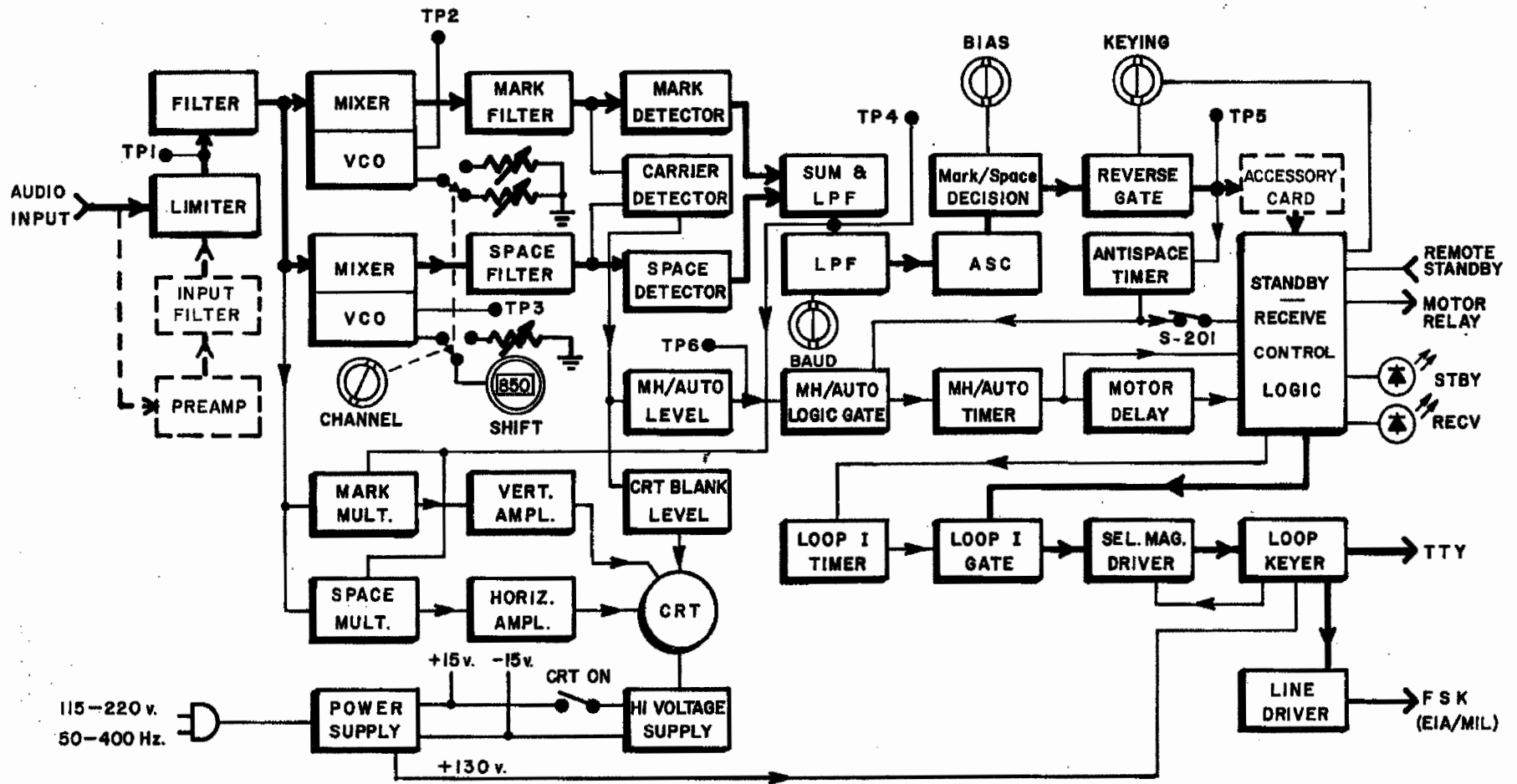
The input of the 400 will accept audio tones in the range of 1000 to 3200 Hz. These tones are first processed by a limiter circuit in order to reduce the effects of noise and establish a constant voltage over a wide range of signal fluctuations. The square wave output of this limiter is filtered by a multipole low pass filter and the resulting sinusoidal waveform fed to two balanced mixers, one for the mark and the other for the space channel. Two independent voltage controlled oscillators (VCO), each operating 3.5 Khz. above the desired mark and space tone frequencies, inject carriers into their respective mixers and heterodyne the incoming signals such that the resulting lower sideband of each occurs at 3.5 Khz. Identical 3.5 Khz. narrow bandwidth filters select only the mark and space tones and reject other frequencies present. The tones are amplified and detected such that the mark tone produces a positive voltage and the space tone produces a negative voltage. These voltages are either summed or fed independently (mark only or space only operation) to a low pass filter where frequencies above the selected baud rate are attenuated. Since signal fading or single channel operation will change the weighting of the detected voltages, an

Automatic Symmetry Corrector circuit following this low pass filter positions the resulting keyed waveform symmetrically with respect to zero voltage. This symmetrical keyed signal is fed to a mark/space comparator which produces a square wave having the same duty cycle as the incoming signal when the "Bias" control is set to "0." Varying the bias control changes this duty cycle, thereby inserting marking or spacing bias into the signal. The detected frequency shift signal thus obtained may be inverted so that the mark frequency produces a space condition, and vice versa, by enabling the reverse gating circuit which follows the M/S comparator.

Thus, the input tones are converted to keyed information ready for acceptance by the teleprinter keying circuits. However, this information will be further processed by the logic circuits in order to minimize receipt of incorrect teletypewriter signals.

4.1.2 Logic, Control & Keying

A carrier detector determines when a signal is present within the bandwidth of the mark and space filters and is used to turn on the CRT display. In addition, this detector feeds the mark-hold/autostart comparator. The space duration of the demodulated output signal is measured by the anti-space timer to determine the length of space pulse being received. This timing information is fed to the standby/receive control logic and is also combined in a logic gate with the output from the mark-hold/autostart comparator. Whenever this comparator in-



NOTE: BOLD LINES INDICATE SIGNAL PATH

SIMPLIFIED BLOCK DIAGRAM, ELECTROCOM MODEL 400 FREQUENCY SHIFT CONVERTER

FIGURE 5

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Theory of Operation

icates that a carrier is present, and the space pulse does not exceed the maximum length allowed for a valid TTY signal, this gate activates the mark-hold/autostart timer. If this timer is activated for the proper period, it sends a receive command to the control logic. If not, the logic remains in a standby condition. Once the receive command has been issued, the timer must be deactivated for its period in order for the logic to return to standby. Upon this return the Motor Delay Timer is started. Unless reset by another receive command, this timer will request the motor turn off after approximately 50 seconds.

The Standby-Receive control logic circuits are programmed by the Keying selector switch and receive information from (1) the Antispace timer, (2) the Mark-hold/Autostart timer, (3) the Motor Delay timer, and (4) the remote standby switch. The TTY keying information coming from the output of the Normal/Reverse gate (or the optional accessory card) is also fed to the control logic circuits. If the information from sources (1) thru (4) indicates that the signal should be received by the teleprinter, the signal is allowed to flow through the Loop Current Gate to the selector magnet driver, the green "Recv" lamp is turned on, and the motor control relay is activated. If conditions (1) thru (4) indicate that the teleprinter should not accept keying information, the control logic will send out only a steady marking signal and the "Stby" indicator will light.

If autostart operation is not selected, the motor control relay operates whenever power is on. When autostart operation is selected, the control logic will turn the motor control relay off after the motor delay timer completes its period. As the relay is turned off, a spacing condition is sent to the loop current gate. However, the loop current timer is simultaneously activated which causes the loop current gate to continue sending a marking signal to the selector magnet driver for approximately 7 more seconds. Current is thereby maintained into the selector magnet until the TTY motor quietly stops. Afterwards, the loop current gate releases and removes all current from the machine.

The selector magnet driver supplies the proper current to drive the keyer. In addition to the keying information supplied through the loop current gate, a voltage is fed back from the keyer circuit which represents the amount of loop current flowing during a marking condition. This voltage is compared in the selector magnet driver so as to provide the proper keyer bias to maintain constant loop current regardless of loop resistance or power line voltage variations. This voltage also switches a line driver which provides keyed constant voltage output of ± 14 volts, suitable for interfacing equipment requiring RS232 or MIL-STD-188C voltage levels.

4.1.3 Monitor

In order to assure accurate and rapid tuning of the incoming signals to the optimum narrow bandwidth filters used in the 400, a Cathode Ray Tube

indicator (Monitor) is included. This circuit monitors the input tones and displays them as a function of the detected signals.

Two multiplier circuits are used as variable gain amplifiers. They receive the incoming tones after being processed by the limiter and low pass filter, and amplify them in direct proportion to the amount of detected signal voltage at the output of the summing amplifier (TP4). The mark multiplier's gain is varied for negative voltages, while positive voltages control the space multiplier's gain. These varying tone levels, which accurately represent the received signal information, are applied to the vertical and horizontal deflection circuits of the CRT monitor. A mark tone produces a vertical line while a space tone produces a horizontal line.

4.1.4 Power Supply

Four power supplies are contained within the 400 equipment. Positive and negative 15 volt regulators supply all voltages to the converter circuitry. They also provide line regulated input to a high voltage supply operating near 20 KHz. which generates 300 and -1000 volts to operate the CRT circuitry. An additional 130 volt dc supply provides the teleprinter loop current which is current regulated by the keyer circuitry as previously described.

In addition to these supplies, a separate transformer supplies 6.3 v. ac to the CRT heater.

4.2 SUBASSEMBLY CIRCUIT OPERATION

The following paragraphs explain in detail the operational theory of the various circuits:

4.2.1 DEMODULATOR CARD

Refer to schematic 400101

4.2.1.1 Limiter

The input signal is normally applied to P1-1 of the Demodulator Card, part number 400-100, and fed to the input of U1. Excessive signal voltages which may damage U1 are clamped by diodes CR1 & CR2. U1 is a high gain operational amplifier which is driven to saturation by voltages as low as 5 mv. rms. If the input applied is in the order of 0 dbm (.778 v. rms) at least 50 db. of limiting is obtained. The frequency response of this limiter is determined by R11 & C2 and is flat for frequencies below 3500 Hz. Potentiometer R7 is provided to null any offset voltage on U1 in order to assure maximum limiter sensitivity.

The output of the limiter is a symmetrical square wave which may be observed at test point #1. It is fed to filter FL1 which provides uniform response to frequencies between 1000 and 3200 Hz. The response of this filter drops rapidly above its cutoff so that the harmonics of the square wave out of the limiter are attenuated and a sine wave is produced. Equalization is also incorporated in this filter to provide reasonably flat overall system re-

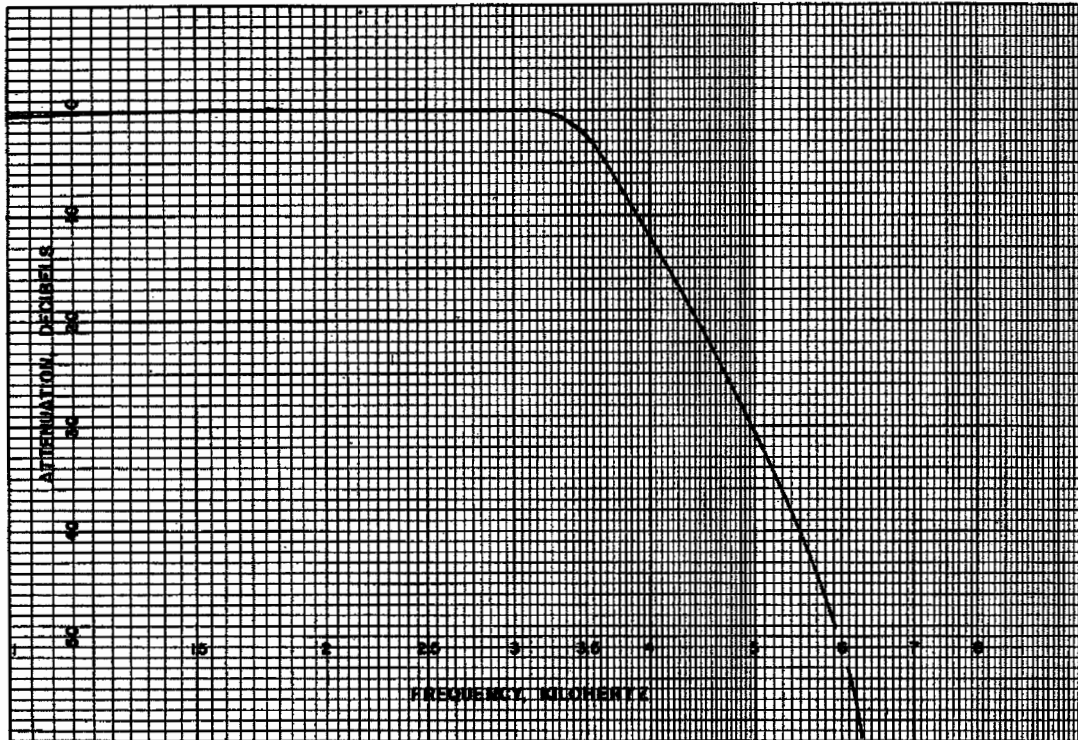


FIGURE 6, 403500 FILTER CHARACTERISTIC

sponse over the entire range from 1000 to 3200 Hz. The typical characteristic curve for this filter is shown in figure 6.

4.2.1.2 Mark VCO/Mixer & Filter

The limited sine wave output of FL1 is fed to U2, the mark VCO/Mixer. Integrated circuit U2 contains a highly linear voltage controlled oscillator, two current switches, a balanced mixer, and two buffer amplifiers. When U2(pin 9) is high, the resistors connected to U2(pin 7) control the VCO timing current (Channel 2). When U2(9) is low, the resistors connected to U2(8) control the timing current (Channel 1). These resistance networks are used in conjunction with capacitor C7 to determine the VCO frequency. All components have been designed to provide temperature compensation, which is of prime importance if frequency stability is to be maintained. The frequency range is from 4500 to 6700 Hz. The VCO output is internally connected to a mixer which is modulated with the incoming sine wave from FL1. This sine wave is applied to U2(1) together with a bias voltage developed at the junction of R13 & R15 which operates the mixer in a balanced condition. Therefore, the output of the mixer section contains primarily the sum and difference frequencies of the signal applied to U2(1) and that of the VCO, with the VCO injection frequency suppressed. The mixer output amplitude is controlled with the Mark Amp control, R14, and fed internally to a buffer amplifier having an output im-

pedance of approximately 750 ohms from U2(2). The frequency generated by the VCO is also buffered, brought out on U2(11) and available at test point TP2.

FL2 is a narrow bandpass, LC filter using toroidal inductors and temperature compensated components. This type of filter was selected because of its high degree of stability and selectivity. The low impedance design (750 ohms) minimizes unwanted noise pickup and "feed around" often encountered with high impedance sections. It has a bandwidth of only 95 Hz., and operates at a center frequency of 3500 Hz. (See figure 7.) Thus, only the mixer product from U2(2) which occurs at 3500 Hz. will be accepted as the mark frequency, and all others will be rejected.

The Channel 1 mark tone is set internally using resistor R19 to set the timing current for the VCO. The Channel 2 mark tone is set internally with R16 in the Model 400. In the Model 402 the timing resistance network is connected to a voltage divider containing a ten turn precision potentiometer, R6, which is mounted on the front panel. This potentiometer varies the timing current and hence the VCO frequency linearly. It contains a digital dial which is continuously adjustable from "000" to "999." The overall span of R6 is calibrated by R41 and R16 so that the dial directly reads the mark frequency which will be accepted. Switch S8 in conjunction with R7 allows R6 to cover the frequency range from 1000 to 2000 Hz., or from 2000 to 3000 Hz.

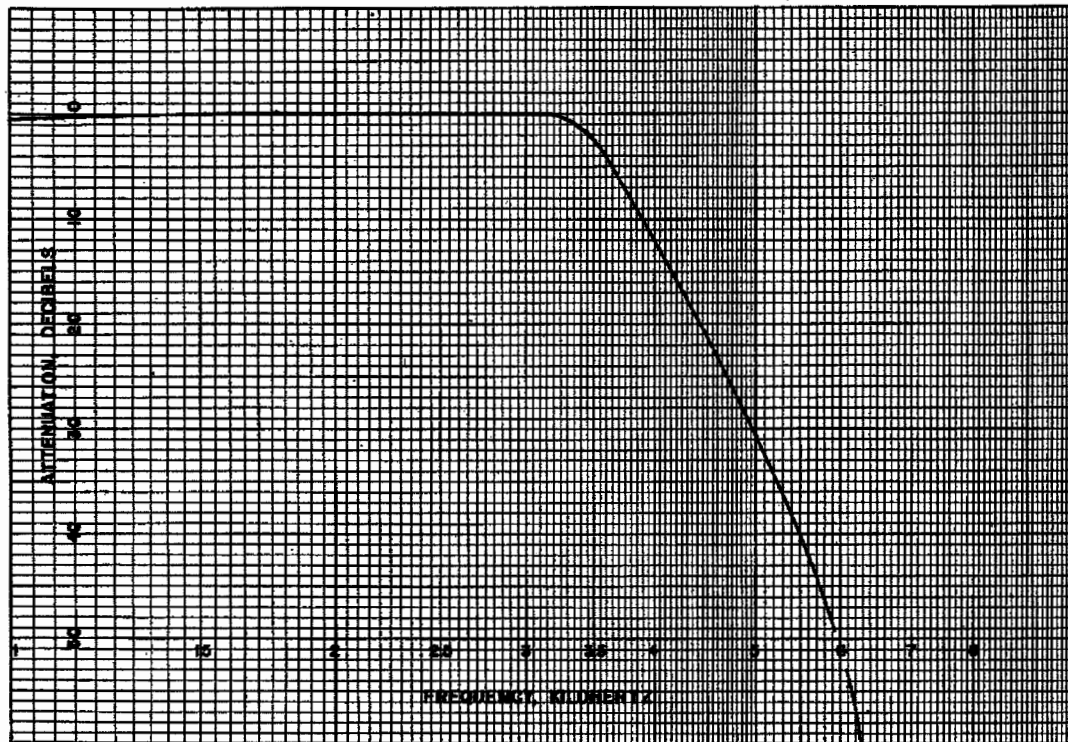


FIGURE 6, 40350 FILTER CHARACTERISTIC

sponse over the entire range from 1000 to 3200 Hz. The typical characteristic curve for this filter is shown in figure 6.

4.2.1.2 Mark VCO/Mixer & Filter

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pedance of approximately 750 ohms from U2(2). The frequency generated by the VCO is also buffered, brought out on U2(11) and available at test point TP2.

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The Channel 1 mark tone is set internally using resistor R19 to set the timing current for the VCO. The Channel 2 mark tone is set internally with R16 in the Model 400. In the Model 402 the timing resistance network is connected to a voltage divider containing a ten turn precision potentiometer, R6, which is mounted on the front panel. This potentiometer varies the timing current and hence the VCO frequency linearly. It contains a digital dial which is continuously adjustable from "000" to "999." The overall span of R6 is calibrated by R41 and R16 so that the dial directly reads the mark frequency which will be accepted. Switch S8 in conjunction with R7 allows R6 to cover the frequency range from 1000 to 2000 Hz., or from 2000 to 3000 Hz.

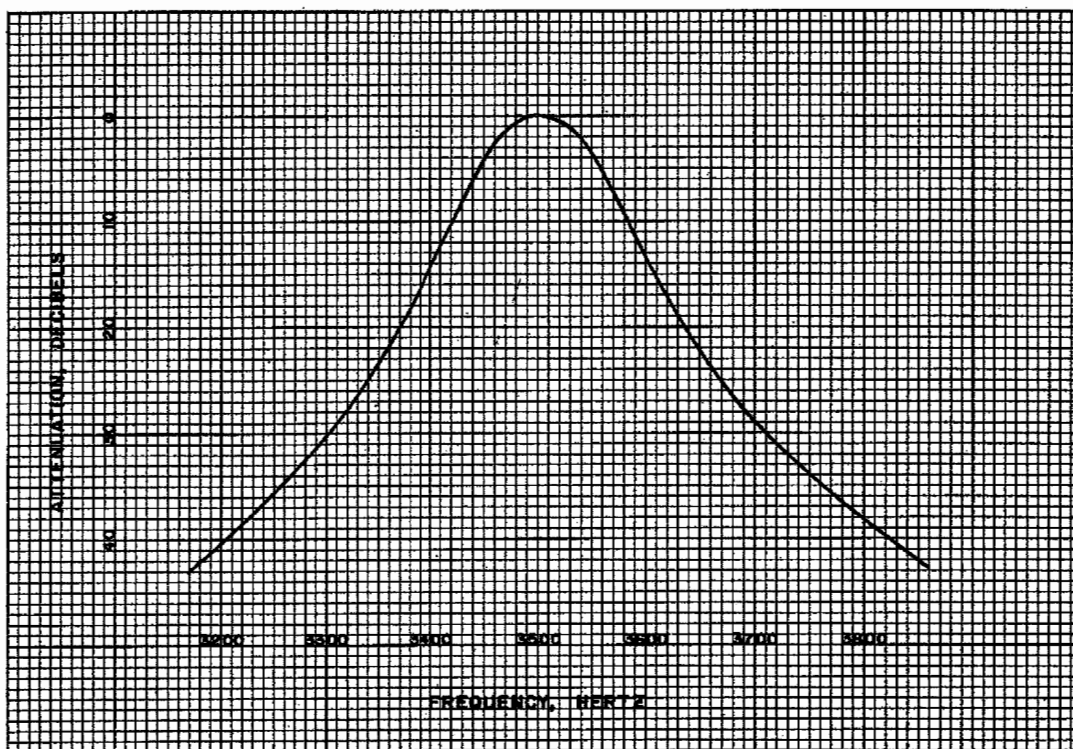


FIGURE 7, MBP 3500-90 FILTER CHARACTERISTIC

4.2.1.3 Space VCO/Mixer & Filter

The limited sine wave from FL1 feeds the Space VCO/Mixer, U3, in exactly the same manner as it feeds the Mark VCO/Mixer U2. The space frequency is determined by R34 for Channel 1. The Channel 2 space frequency of the Model 402 is variable from the front panel utilizing R1, which is calibrated by R31 and R40, in the same manner as the Model 402 mark frequency. The Channel 2 space frequency on the Model 400 operates in a similar manner using R1 for the front panel adjustment; however, the digital knob is calibrated as the difference in frequency between the internal Channel 2 mark frequency setting and the space frequency set by R1. This direct reading of "Shift" is given in Hertz. When S3 is in the "High" position the space VCO is operated above the frequency of the mark VCO by the amount of shift. When in the "Low" position, the space VCO is operated below the mark VCO frequency.

Filter FL3 selects the space frequency in the same manner as FL2 selects the mark frequency. These identical filters, both operating at 3500 Hz., assure equal signal delays and pulse reception characteristics for both mark and space frequencies, which is difficult to obtain with filters operating at different center frequencies.

4.2.1.4 Mark & Space Channel Amplifiers

The mark and space tones are amplified by linear amplifiers U4 and U5 respectively. The AC

gain of these amplifiers is temperature compensated by thermistors RT1 & RT2 to offset the output amplitude versus temperature characteristics of U2 and U3.

4.2.1.5 Detectors

Diodes CR7 & CR8 in conjunction with R65 rectify and combine the mark and space tones in order to show presence of signal in the tone channels. This simple square law carrier detector is used to provide information to the logic and blanking circuits.

In order to provide a large dynamic range and full wave rectification, the keyed signal information is detected by two precision linear detectors, U6 & U7, and a summing amplifier, U10. The mark detector U6 produces a positive output while space detector U7 produces a negative output at the summing junction, P1-9. Summing amplifier U10 inverts these polarities and also provides low pass filtering.

The operation of the mark and space detectors is the same except for polarity. Therefore, only the operation of the mark detector will be described. The mark detector operates when its output which appears on P1-8 is connected through the front panel "Channel" selector switch and P1-9 to the inverting input of U10. The sine wave output of U4 (pin 6) is fed through two paths into the summing junction of U10 where the waveforms are combined and appear as a negative full wave rectified voltage

at TP4. Path "1" feeds amplifier U10 thru input resistor R64. Path "2" feeds thru R60 to an inverting operational amplifier, U6, which provides linear half wave rectification. For negative voltages into R60, U6 produces a positive output and CR6 conducts thru feedback resistor R62 to produce unity gain ($R62/R61=20K/20K=1$). For positive inputs CR6 disconnects and the feedback current thru CR5 holds the input of U6 at ground. Therefore, negative values of signal produce corresponding positive output voltages at the junction of R62 & CR6, while positive values produce no output. This half wave rectified signal from path "2," 180 degrees out of phase from the signal of path "1," is fed to U10 thru input resistor R63. R87, the feedback resistor for U10, is common to both paths. Therefore, the gain of U10 to path "2" is $R87/R63$, the gain to path "1" is $R87/R64$, and the magnitude of the out of phase signal resulting from path "2" will be twice that of path "1." ($R87/R63 \div R87/R64 = R64/R63 = 20K/10K = 2$) The summation of these two waveforms results in the cancellation of the positive component and a negative full wave rectified voltage is produced at TP4. Capacitor C20 in conjunction with R87 provides one section of low pass filtering having a cutoff of 66 Hz. to smooth the full wave rectified voltage into DC.

The action of the space detector is the same except polarities are reversed so as to produce a positive output at TP4 upon detection of the space signal. The DC voltages produced at TP4 will correspond directly to the amplitude versus frequency characteristics of the mark and space channel filters.

Since detector summing occurs at the input junction to U10, the outputs from the mark (P1-8) and space (P1-7) detectors are fed through the "Channel" selector switch to the summing junction. When "mark only" or "space only" operation is selected, only the output from one of these detectors is applied. Since the summing junction has the ability to sum several voltages simultaneously, additional detectors from another 400 converter may also be connected to P1-9 to provide diversity operation.

4.2.1.6 Display Multipliers

Operational multipliers U8 & U9 multiply the incoming signal, after processing by the limiter and lowpass filter, by the detected mark and space voltages produced at TP4. Each multiplier is balanced by adjusting the M bal (R69) or S bal (R78) control so that no output signal occurs at pin 11 for zero input voltage at pin 3. When balance is upset by a positive or negative voltage, an output occurs at pin 11 which is the product of this voltage and the signal voltage applied to pin 5. CR9 allows only the negative component of the detected signal voltage to control the mark display multiplier, U8, while CR10 provides positive voltage control of the space multiplier, U9. Since the resultant outputs of U8 & U9 are products of the input signals and the detected signals from the channel filters, the voltages

produced give an accurate indication of the quality of the input and keying signals as well as how precisely the filter channels are tuned to the incoming tone frequencies. The output of U8 appears at connector P1-20 where it is fed to the vertical amplifier of the CRT monitor, and the output of U9 is fed to the horizontal CRT amplifier from P1-22. These voltages are displayed on the CRT as a vertical line when a mark tone is present, and a horizontal line when the space tone is present. Should the operator prefer that the mark tone present a horizontal line and the space tone a vertical line, this pattern is easily obtained by reversing the directions of CR9 and CR10.

4.2.1.7 Preamplifier

Circuitry for an optional preamplifier (U11) is contained on the Demodulator Card. This preamplifier is normally not required due to the large dynamic range of the limiter. However, when optional input filters are used, it provides optimum filter impedance matching and increases the input sensitivity to overcome filter insertion loss. When the input filters are switched out, a .22 mfd. capacitor is connected from P1-21 to P1-1 to attenuate frequencies below the operating range of the converter. Diodes CR11 & CR12 provide input protection to U11 and will provide limiting action above +15 dbm.

4.2.2 LOGIC CARD

Refer to schematic 400201.

4.2.2.1 Baud Rate Low Pass Filter

The demodulated signal produced at TP4 and P1-L of Demodulator Card 400-100 is connected to the low pass filter input, P2-13, on the Logic Card, p.n. 400-200. U1 in conjunction with R1, R2, R3, C1 & C2 provide an active low pass filter. Additional capacitors are placed in parallel with C1 by the Baud rate switch in order to provide the optimum cutoff frequency for the baud rate selected. The 3 db. cutoff frequency resulting from the combined low pass filter sections occurs at six tenths the baud rate. This filter produces a sine wave from a keyed square wave having a frequency equal to one half the baud rate.

4.2.2.2 Automatic Symmetry Corrector

Following the low pass filter is an Automatic Symmetry Corrector circuit which positions the keyed waveform symmetrically with respect to ground. In the event of signal fading and/or loss of one of the tones completely, this circuit positions the remaining signal waveform so that comparator U2-1 makes a valid mark/space decision with a minimum of bias distortion. This ASC circuit allows "semi-diversity" operation in that the 400 can copy on mark only, space only, or combined information simultaneously. It also allows independent copy of mark only or space only signals if one channel is disabled.

When a mark signal is present the output of U1

is negative and current flows thru CR3, R6, R5, and CR2 to ground. CR1 is reverse biased allowing C3 to be charged. Since R5 & R6 are equal in value, the voltage at their junction will be negative and one half of the voltage out of U1. Removing the mark tone causes the U1 output voltage to drop to zero. As soon as this voltage drops to half value, the charge on C3 circulates current thru R5 & R6, creating a positive voltage at their junction. With zero voltage out of U1, C3 will produce one half of the original input voltage, but of opposite (spacing) polarity. Thus, if a keyed mark only signal is presented to the ASC circuit, a signal of $\pm\frac{1}{2}$ value will be produced that is symmetrical with respect to ground. Similar action takes place for a positive voltage (spacing signal) out of U1 except the current flows thru CR1, R5, R6 & CR4 to ground; CR3 is reverse biased; and C4 is charged.

When a full transition from mark to space occurs, the positive current produced from U1 is added to that released from C3 producing full positive voltage at the junction of R5 & R6. Likewise, a full space to mark transition will produce full negative voltage. The time constants chosen for this ASC circuit maintain symmetry of the keyed waveform with respect to ground reference during fading and partial signal loss.

4.2.2.3 Mark/Space Comparator

U2-1 serves as a comparator which makes the final Mark/Space decision. This comparator is balanced with respect to 0 voltage when the "Bias" control is set to "0." Any negative voltage (mark) from the ASC circuit produces a logic "0" (low, zero volts) while any positive voltage (space) produces a logic "1" (high, +15 v.). Adjusting the "Bias" control will upset the comparator balance and shift the decision point from zero reference. As a result of the low pass filter, keying transitions into the comparator follow a sine curve. Shifting the comparator balance will cause the decision to occur higher or lower on this curve. Higher decision voltages decrease the interval between the mark/space to space/mark transitions, thereby producing marking bias on the output waveform of the comparator. Likewise, negative decision voltages decrease the interval between the space/mark to mark/space transitions and introduce spacing bias.

Because of the high gain of this comparator circuit, very small deviations from zero voltage will cause the comparator to make a decision. During weak signal conditions whereby the signal fades into noise, random noise pulses could produce errors. To provide a threshold which must be overcome before noise can effect the comparators decision, hysteresis has been applied to U2-1. Positive feedback through R12 provides this decision threshold hysteresis and also improves the switching action of the comparator.

4.2.2.4 Reverse Gate

The output signal from U2-1 contains complete

keying information. In order to quickly reverse the sense of shift when receiving an inverted signal, U2-2 and U4 provide reverse gating. Grounding P2-S causes the output at P2-3 and TP5 to be positive for a mark tone frequency, thereby causing the mark frequency to produce a spacing condition. For all positions other than "Reverse" on the keying selector, P2-S remains high and the output signal is zero for mark.

4.2.2.5 Antispace Timer

An antispace timer samples the signal output in order to determine that the space interval does not exceed that allowed for a valid teletype signal. A positive space condition charges C8 thru R17 & R18 causing U3-1 (pin 10) to go low if the space interval is excessive. Upon receipt of a low marking condition, C8 is rapidly discharged thru R15 and U3-1 (10) goes high. This "antispace" signal is applied to the control logic at U5-2(1) as well as to the Mark hold/Autostart timer gate, U6-3(9).

4.2.2.6 Autostart and Blanking Comparators

The signal from the carrier detector is applied to P2-4, filtered thru R23, C5, R24 & C6 in order to reject noise and CW keying, and applied to the inputs of the Autostart Level comparator and the CRT Blanking comparator. R21 sets the threshold at which U3-2 (pin 9) goes high, indicating a signal in the channel. This point is easily monitored at TP6. In a similar manner, R29 sets the level at which U2-3 (pin 9) goes high thereby charging C7 thru R31 and CR6. U2-4 provides high output at P2-C which is used to turn the CRT trace on. When signals drop below the threshold setting of U2-3, CR6 becomes reverse biased and C7 discharges through R32 to maintain the CRT trace for approximately 1.5 seconds. U2-4(10) then drops P2-C to zero, extinguishing the CRT display.

4.2.2.7 Mark-hold/Autostart Timer

Gate U6-3 controls the Mark-hold/Autostart timer. Whenever the carrier is detected (U6-3 pin 8 high) and valid space conditions exist (U6-3 pin 9 high), the output of this gate goes low. When operating in the Mark-hold mode, the series combination of C9 & C10 is discharged thru R37 and U3-3(5) goes high. If neither condition is met, U6-3(10) remains high, charging C9 & C10, and U3-3(5) goes low. The same action takes place for the Autostart mode except the time constant is increased by shunting C10 with transistor Q1. Approximate time constants for mark-hold and autostart modes are 1.3 & 3.6 seconds respectively. This timer is designed so that the turn on and turn off time constants are approximately the same. When the keying selector is in the "Normal" or "Reverse" positions this timer is disabled by placing a ground on P2-R. The timer output is applied to the control logic thru U5-2(8) and must be high in order for the keying circuits to be placed in a receive condition.

NOTE: In some autostart systems, particularly on vhf where noise and interference are a minimum, it may be preferred to reduce the time constant when operating in the "Autostart" mode. This is easily accomplished by removing transistor Q1 from its socket. The Autostart and Mark-hold time constants will then be the same, approximately 1.3 seconds.

4.2.2.8 Motor Delay Timer

Whenever the output of U3-3 is high indicating a "receive" condition, the motor delay timer is turned on, causing U3-4(4) to go high. This timer turns on rapidly with a positive signal; however, when the signal drops to zero the timer requires approximately 50 seconds to turn off. This timer output is fed to the control logic at U5-3(12) after being inverted by U6-1. The control logic will use this information to maintain the motor running for 50 seconds after completion of an autostart message. Accessory card circuitry can override this timer and hold the motor off by placing a low on U6-1(1).

4.2.2.9 Accessory Card Enable

Installing an accessory card within the 400 grounds P2-2, which breaks the signal flow from U4-4 to U5-1. The demodulated signal appearing on P2-3 then feeds this card. The accessory card's signal output connects into the control logic through P2-5.

4.2.2.10 Control Logic

Integrated circuit U5 provides the control logic for the converter. U5-1 controls the signal flow, U5-2 controls the indicator lamps, and U5-3 provides motor control. When signals from the antispacer timer, mark-hold/autostart timer and local standby lines are high, U5-2(9) goes low turning Q3 off and extinguishing the "STBY" lamp. U6-4(11) goes high enabling the signal gate U5-1(5) and turning Q2 and the receive indicator lamp on. Should any of these control signals go low, U5-2(9) goes high, the standby indicator turns on, and the keyed signal to the teleprinter is held marking. In addition, U6-4(13) will go low when the remote standby line is grounded, thereby causing the "RECV" and "STBY" indicators to light simultaneously. A contact bounce filter is provided on the remote standby line consisting of R64 and C12. Diode CR9 serves to block any positive voltages above 15 volts from damaging U6-4. This allows the remote standby line to be controlled by a keying voltage such as might be obtained from the push to talk line of an associated transmitter. Zero voltage will place the 400 in "standby" while a positive voltage will provide "receive" operation. When using this method of control, it is necessary to provide a diode between the push to talk voltage source (anode connection) and the control switch (cathode connection) to prevent the PTT supply from acting as a return path to the remote standby connection when

transmitter power is turned off. The control switch may then be connected to both the transmitter PTT and the 400 remote standby lines simultaneously.

When operating in the autostart mode, P2-X is grounded causing U6-2(4) and U5-3(11) to go high. When a signal is not present U5-3(12) is high, and U5-3(13) remains high as long as the converter is not placed in a standby condition. Simultaneous application of these three high inputs to U5-3 produce a low output on U5-3(10). This low turns Q4 and the motor control relay off. If an autostart signal is received, the input on U5-3(12) goes low. A local or remote standby condition causes U5-3(13) to go low. Placing the keying selector in any position other than "Autostart" causes U5-3(11) to go low. Any of these three conditions will cause U5-3(10) to go high thereby placing a high on U7-1, U7-2, and Q4. Q4 then operates the motor control relay applying power to the teleprinter.

4.2.2.11 Loop Current Timer and Control Gate

The loop timer, U7, is a monostable timer which is triggered by a high to low transition from U5-3. As long as the motor is turned on, U7-1 is enabled and responds to the keying voltages from U5-1. The loop current control gate U7-4 is enabled by a high from U7-3(11) allowing the keyed signal from U7-1 to pass thru U7-4 and out of the logic card to the keyer. When the motor control gate U5-3 turns off, U7-2(10) goes high charging capacitor C13 and placing a high on the input of U7-3. This in turn causes U7-3(11) to go low which places the output of U7-4 high. The result of this action is to maintain the loop current on. As soon as C13 discharges thru R60, the output of U7-3(11) goes high. Since the output from U7-1 is also high, U7-4(4) goes low and places the keyer in a zero current, standby condition. The time constant is approximately 7 seconds. This allows sufficient time for the teleprinter motor to quietly coast to a stop before loop current is removed from the selector magnet. If greater time is required, increase the value of R60.

4.2.3 MONITOR CARD

Refer to schematic 400301.

4.2.3.1 Deflection Amplifiers

The vertical and horizontal CRT information obtained from the display multipliers (ref. section 4.2.1.6) is applied to P3-1 and P3-3 respectively. Each signal passes thru a gain control and into its differential deflection amplifier. Centering of the CRT traces is obtained by adjusting the DC balance of these amplifiers with positioning controls R8 & R11. Approximately 300 volts is applied to the deflection circuits from the on board power supply, PS301. The emitter current of each amplifier is held relatively constant by U1 which is connected to form two "current mirror" circuits. R19 & R20 establish the mirror currents controlling the horizontal and vertical amplifiers respectively.

4.2.3.2 CRT Blanking

A CRT blanking circuit extinguishes the trace when the incoming signal falls below the level set by the blanking comparator (ref. section 4.2.2.6). With no signal present, optical coupler OC1 is turned on by current flowing thru R34. The light emitting diode within this coupler causes its phototransistor to conduct, connecting the base of Q5 to the junction of R28 & R29. Current flowing thru R28 forward biases Q5, lowering its collector voltage to slightly above its emitter voltage. The voltage developed between J301-3 & J301-9 biases the grid of the CRT to cutoff, extinguishing the trace.

When a signal is present, Q6 conducts and lowers the current into OC1. The LED and phototransistor turn off, removing forward bias from Q5. The voltage on the collector of Q5 raises to the setting of R30, removing the cutoff bias on the CRT and establishing the proper operating bias for a visible trace. Should a failure occur in the LED of OC1, the trace will remain on so that the usefulness of the CRT will not be impaired. The operating bias of the CRT is adjusted automatically with respect to ambient light by resistance photocell PE1. As light intensity is increased, the resistance from the clockwise end to the wiper of R30 is reduced, thereby reducing the grid bias to the CR tube and increasing its trace intensity.

4.2.3.3 High Voltage Power Supply

In order to obtain a sharp, bright trace a total of 1300 volts is applied to the CRT circuit. Since the deflection amplifiers transistors must be operated below 350 volts, the control grid of the CRT is operated at 1000 volts below ground. High voltage supply PS301, operating near 20 Khz., provides positive 300 and negative 1000 volts. In order to maintain a constant size trace regardless of AC line voltage variations, this high voltage supply obtains its 30 volt input from the regulated plus and minus 15 volt power supplies. Its input circuit is filtered to prevent radiation or interference to other circuits within the converter. Transformer T301 provides CRT heater voltage while maintaining isolation of the -1000 v. heater potential.

4.2.4 POWER/KEYER CARD

Refer to schematic 400401.

4.2.4.1 Power Supplies

The Power/Keyer Card p. n. 400-400 receives voltages from three secondary windings on the power transformer. One winding supplies 23 vac to a

full wave bridge rectifier CR1. The resulting dc is filtered by C1 and regulated by a three terminal regulator, U1. The unregulated voltage across C1 also supplies control current to the solid state motor relay. The output of regulator U1 supplies positive 15 volts to all of the converter circuitry. Another 23 volt winding feeds rectifier CR2, C2 and U2 to produce regulated 15 volts that is negative with respect to ground. 110 volts from the third winding is rectified by full wave bridge CR3 and filtered by C5 to produce an unregulated loop current supply for operating the teleprinter selector magnets. This supply produces about 130 volts when loaded to 60 ma. for a line voltage of 110 vac. Unloaded voltage will be approximately 175 v dc.

4.2.4.2 Selector Magnet Driver and Keyer

The selector magnet driver and constant current keyer produce neutral keyed current into the teleprinter. The loop current flowing thru R10 produces a voltage which is fed back to the negative input of U3, while the keying voltage from the logic card provides a reference voltage for the positive input. R5 adjusts this voltage in order to set the proper amount of loop current. Any error between these voltages will vary the drive to Q1 in order to maintain equilibrium, thereby holding the loop current constant regardless of load or voltage variations. Q1 operates in its active region and provides the resistance required to maintain the proper loop current.

The collector of Q1 connects to the positive loop supply voltage. The selector magnet is placed between the negative return and ground in order to minimize the potential between the selector magnet and the teleprinter cabinet. C8 and R4, which shunt the external loop circuit, suppress high voltage transients generated by the back emf of high inductance selector magnets. This network and a metal oxide varistor (MOV) located on rear terminal strip J6, protect the keying transistor from possible damage.

4.2.4.3 FSK Voltage Driver

The loop current sensed across R10 also feeds a voltage to the inverting input of U4. Negative 14 volts is produced at the output of U4 when the loop is marking, and positive 14 volts when spacing, thereby providing EIA RS232C voltage levels. When MIL-STD-188C output levels are required, the polarity of the input terminals to U4 must be reversed on the PC card. The output voltage from U4 is reduced to 6 volts by adding R15.

SECTION 5, MAINTENANCE

5.1 GENERAL

The 400 equipment has been designed to provide long term trouble free operation with a minimum of maintenance. Conservative design and the use of quality components throughout add to the overall reliability of this product. Access to all test points and adjustments is readily available by removing only the covers. Each cover slides to the rear of the unit and out of the grooves holding it in place, after removing the two screws which secure its flange to the rear panel.

Two quick acting fuses protect the 400 from overload. The 3/8 amp fuse provides protection during 115 volt operation, while the 3/16 amp fuse provides 230 volt protection. When operating on 230 volts, both fuses are connected in series; and therefore, both must be operable. For 115 volt operation, the 3/16 A. fuse is not required.

5.2 CARD & COMPONENT REPLACEMENT

Should a failure occur, the fault may be localized to an individual printed circuit card, and this card removed for servicing or replacement. Spare cards are available to allow rapid field servicing by substitution. The defective card may then be returned to a service center or the factory for repair. In addition, IC's and transistors are mounted in sockets wherever practical, and may be removed, for checking or replacement without desoldering.

Figures 8 and 9 show the location of the printed circuit cards within the 400 as well as various main frame components.

5.2.1 Card Removal

Before removing any cards, unplug the power cord to prevent the possibility of shock or component damage. To remove a circuit card, remove the two screws holding its outer edge to the card support rails. Holding the card by its edges, gently lift it slightly upward and pull it away from the side panels, thereby removing it from its connector. Do not remove the card by pulling on the filter cans or other components. Both the Monitor and Power/Keyer cards contain on board connectors which attach to the CRT socket and power transformer respectively. Before removing these cards, disengage these connectors by depressing their locking tabs and pulling upwards.

5.2.2 Card Installation

Each connector is keyed so that it will accept only the correct card. When installing a circuit card, align the keyways of the card and connector, place the card into the connector slot, and gently push from the edge opposite the contacts until it is properly seated into the connector. Install the two mounting screws firmly into the support rails to assure

that the card cannot vibrate loose. Whenever installing a card, inspect the edge contacts and remove any grease or dirt which may exist. Dirty contacts may cause improper operation and system failures. Remember to install the CRT and transformer connectors when replacing the Monitor and Power/Keyer cards.

5.2.3 CRT & Sensor Replacement

To remove the Cathode Ray Tube disconnect its cable from the Monitor card. With the base of the CRT still clamped, pull the socket from the tube. Remove the two Phillips head screws in the face of the CRT bezel. Pull the bezel straight forward to avoid damage to the photocell mounted underneath. While supporting the CRT, release the base clamp and remove the tube through the front panel opening.

The Automatic Intensity Control sensor (PE1), mounted in a socket under the lower right hand corner of the bezel, is removed by pulling it forward. The resistance of this photocell will be above 5 megohms in total darkness and will drop to less than 400K ohms under bright light. If automatic intensity control is not desired, it may be disabled by removing PE1. The CRT intensity will then be controlled only by R30 on the Monitor card. In the event of failure of this circuit, inspect the connections to resistor R35 shown on schematic 400301. This 100K resistor which is in series with PE1 is mounted on the rear of the photocell socket, and is covered by insulated tubing.

When installing the CRT, insert it into its shield until the tube face is about one half inch behind the front panel. Insert PE1 into its socket and align this photocell with the hole provided in the bezel. Push the bezel straight against the panel so that PE1 is properly seated, and fasten with the two Phillips head screws previously removed. Gently push the CR tube forward until its face seats against the cushion within the bezel, and clamp the base. Plug the tube socket back on the CRT and the cable connector into its socket on the Monitor card.

5.2.4 Knobpot, Knob, and Lamp Replacement

The digital knob on the "Shift" or "Freq" controls is part of a "Knobpot" assembly. This integral 10 turn potentiometer and digital turns counting dial snaps into a cutout in the front panel. It is locked in place by four self contained plastic spring fingers which extend from the sides of the knobpot housing. If replacement of this assembly is required, remove all connections from the rear of the potentiometer, depress the plastic fingers, and push the knobpot forward and out of the panel.

The remaining front panel knobs are each attached by two hex socket set screws. A hex wrench is most easily inserted into these screws after re-

moving the extrusion which forms the bottom of the front panel frame. This extrusion is held in place by four Phillips head screws which are accessible after removing the bottom cover.

Each front panel LED indicator is mounted in a socket, and may be unplugged after unscrewing the small knurled collar which holds it in place. Upon replacement, note that the flat side of the LED (negative lead) mounts adjacent to the socket keyway.

5.2.5 Component Removal

Figures 10, 11, 12, and 13 show the location of the various components on the printed circuit cards. In addition, a legend is printed directly on the card adjacent to each component to facilitate identification. The components are securely soldered into plated thru holes. Should removal be necessary, use a pencil type of soldering iron operating at a temperature of 370° C (700° F) or less and "solder wick" to absorb the solder. Place the "solder wick" over the connection to be removed, and place the iron on top in order to provide heat. The solder wick will draw the solder from the connection after which the component may be removed. Slight additional heating of the component lead may be required during removal; however, be careful not to overheat the pad, or force removal, as permanent damage to the card may result.

5.3 PRELIMINARY ADJUSTMENTS

5.3.1 Before making any adjustments, check the power supply voltages to assure that the regulators are operating properly. +15v. test points are located on the ends of R27 & R37 adjacent to the GND test point on the Demodulator card, on CR1 of the Monitor card (when the CRT is turned on), adjacent to U1 on the Logic card, and on contact N of the Power/Keyer card. Identification legends are shown at each of these locations. -15v. test points are located on the end of R8 near TP1 on the Demodulator card, on R9 of the Monitor card, and on contact M of the Power/Keyer card. Voltage measurements at these points are referenced to GND test pins or chassis. The reading of the positive supply should be $+15 \pm 0.6$ volts, and the negative supply should read -15 ± 0.6 volts. These voltages should remain constant over a line voltage variation from 100 to 135 volts (or 200 to 270 volts).

The 130 volt loop power supply may be checked between the positive and negative terminals of C5 on the Power/Keyer card. This voltage is not regulated and will vary between 125 and 195 volts depending upon the loop current and power line voltage.

5.3.2 All internal adjustments and calibration have been performed during factory testing. Should a loop current other than 20 ma. be required, adjust R5 on PC card 400-400 as described in section 3.1. The CRT trace may be adjusted as described in section 3.3.3. Channel 1 frequency calibration is

outlined in section 3.3.4. The simplified adjustment procedure outlined in section 5.4 will allow minor Demodulator adjustments without the use of test equipment. However, to assure factory specifications the complete "Laboratory Calibration" described in section 5.5 is required.

5.4 SIMPLIFIED DEMODULATOR ADJUSTMENTS

1. Set Channel switch, S2, to 2; Keying switch, S1, to Normal; and Power switch, S5, to CRT. Model 400: Set Shift control, R1, to 850, and range switch, S3, to High. Model 402: Set Mark Freq. control, R6, to "125"; Space Freq. control, R1, to "975"; and both range switches, S7 & S8, to 2K.
2. Adjust the input tone to 2125 Hz. which should provide a peak indication on the vertical CRT trace.
3. *M-Bal adjustment.* Place S2 to "2S." Only a dot should appear on the CRT. If a small vertical line appears adjust M-Bal (R69) for null.
4. Adjust input frequency until the maximum length horizontal trace appears. This should occur at 2975 Hz.
5. *S-Bal adjustment.* Place S2 to "2M." Only a dot should appear on the CRT. If a small horizontal line appears adjust S-Bal (R78) for null.
6. *M-Amp adjustment.* Return input tone to the mark frequency of 2125 Hz. as indicated by a maximum vertical trace. Adjust M-Amp (R14) CW until further adjustment has no effect on trace length. This is the saturation level of the mark channel amplifiers. Turn R14 CCW until the trace length shortens slightly below the saturation level by about 2 to 4 mm.
7. *Frequency calibration check.* Set S2 to the "2S" position. Model 400: Turn R1 full CCW to "000." Model 402: Set R1 to "125." If the Shift (Model 400) or Space Freq. (Model 402) control is calibrated properly, a 2125 Hz. input tone will provide a full length horizontal trace. The frequency calibration of the Mark Freq. control, R6, on the Model 402 may be checked by placing S2 in the "2M" position, setting R6 to "975," and observing if a 2975 Hz. input tone produces a maximum length vertical trace. Afterwards, return S2 to "2S" and R6 to "125."
8. *S-Amp adjustment.* Check for saturation of the space amplifiers by adjusting S-Amp (R28) CW until further adjustment has no effect on trace length. Then turn R28 CCW until the horizontal trace shortens 2 to 4 mm. below the saturation level.

9. **Channel balance adjustment.** Place S2 at "2." A dot will appear on the CRT if both mark and space channels are balanced. (If a dc voltmeter is available, balance will best be indicated by a reading of zero volts at test point TP4.) If a horizontal line (or positive voltage at TP4) appears, reduce R28 until balance is obtained. If a vertical line (or negative voltage at TP4) appears, reduce R14 to obtain balance.
10. CRT trace lengths may now be adjusted. Apply an input tone of 2125 Hz. and set the Monitor gain controls as described in section 3.3.3.3. After this adjustment, return S2 to "2," and front panel control R1 on the Model 400 to "850" or on the Model 402 to "975."
11. **Limiters balance adjustment.** While receiving the mark frequency, reduce the tone amplitude into the 400 until the vertical trace shortens. This will occur below 10 mv. rms. Adjust LIM balance control (R7) until the maximum trace length is obtained.

5.5 LABORATORY CALIBRATION

The following adjustments have been performed at the factory and will not normally be required in the field unless the controls have been tampered with or a component has failed. These adjustments should be made only by a qualified technician who is familiar with calibration procedures.

5.5.1 DEMODULATOR CARD, P. N. 400-100, ADJUSTMENTS

5.5.1.1 Limiter Adjustment

Feed a tone of approximately 2000 Hz. at 1 v. rms into the audio input, connector J5. Using an oscilloscope, observe the waveform at test point TP1. A square wave corresponding to the input frequency should be observed. Reduce the amplitude of this voltage to less than 5 mv. until the square wave approaches a sine wave. Adjust the LIM balance control R7 so that the duty cycle of this waveform is symmetrical and both the positive and negative peaks display equal amounts of clipping. As the amplitude is increased the waveform will increase in squareness. Complete limiting as observed by a sharp square wave should occur at a voltage of about 5 mv. rms. Increasing the amplitude of the input voltage above this point will have very little further effect on the limiter output waveform at TP1.

5.5.1.2 VCO Adjustments

Connect a frequency counter to TP2 in order to measure the output frequency of the Mark voltage controlled oscillator (VCO). With the Channel switch placed in the "1" position this frequency should be adjustable throughout the range of 4500 to 6700 Hz. by varying the M-1 control, R19. Set

R19 to produce a frequency of approximately 5500 Hz. Next, connect the counter to TP3 and measure the output frequency of the Space VCO. This frequency should also be adjustable over the range of 4500 to 6700 Hz. by varying the S-1 control, R34. Set R34 to produce a frequency of approximately 5500 Hz.

5.5.1.3 Mark Filter Center Frequency

Connect a dc voltmeter or oscilloscope to TP4. With Channel switch S2 in the "1M" position, adjust the incoming tone frequency until the maximum negative voltage is obtained at TP4. Before final adjustment, set the mark amplitude control, R14, so that the voltage at TP4 is about -12.5 volts. Although this setting is not critical, the voltage must be below the saturation level of the mark amplifier or the exact point of maximum voltage will not be noticeable. Careful adjustment of the incoming frequency will be required, since the voltage being measured is controlled by the selectivity of the mark filter. Once the peak negative voltage is established, use the counter to measure the frequencies at test points TP1 and TP2. Subtract the reading at TP1 from that at TP2 in order to obtain the exact center frequency of the mark filter, FL2. This frequency should be 3500 ± 20 Hz., and will be referred to as FL2_{cf}.

5.5.1.4 Space Filter Center Frequency

Place the Channel switch S2 in the "1S" position and adjust the incoming tone frequency to produce the maximum positive voltage at TP4. Before final adjustment set the voltage at TP4 to about +12.5 volts with the space amplitude control, R28, to assure the peak reading is noticeable. Once the peak voltage is established, measure the frequencies at TP1 and TP3. Subtract the TP1 from the TP3 reading to obtain the exact center frequency of the space filter, FL3. This frequency should be 3500 ± 20 Hz. and will be referred to as FL3_{cf}.

5.5.1.5 Channel 1 Calibration

The Channel 1 frequencies are easily set by adding the desired mark frequency to FL2_{cf} as obtained in section 5.5.1.3. Place the counter at TP2 and adjust M-1 (R19) until the proper frequency is obtained. For example, if FL2_{cf} is 3502 Hz. and the mark channel is to be set to 2125 Hz., adjust R19 until a frequency of $(3502 + 2125 =) 5627$ Hz. is obtained. This frequency should be adjusted to within ± 4 Hz. In a similar manner, adjust S-1 (R34) until the proper frequency is obtained at TP3 resulting from the sum of FL3_{cf} and the desired space frequency.

5.5.1.6 Channel 2 Shift Calibration, Model 400

Place the Channel switch S2 in the "2" position, the range switch S3 to the "High" position, and the digital Shift knob to the extreme clockwise setting of "000" which represents 1000 Hz. Attach the counter input to TP3 and adjust control S-2

(R31) until the frequency of 3125 plus $FL3_{cf}$ is obtained. (Approximately 6625 Hz.) Next, turn the shift control (R1) fully counter-clockwise to "000." Adjust the space range control R40 until a frequency of 2125 plus $FL3_{cf}$ is obtained at TP3. (Approximately 5625 Hz.)

Place S3 in the "Low" position. The frequency at TP3 should remain within 5 Hz. To correct a greater error, the value of R2/R2A will have to be matched more closely to the overall value of potentiometer R1.

Calibration linearity should next be checked by setting R1 at the 100, 200, 300, etc. settings and observing if the VCO frequency at TP3 decreases in 100 Hz. increments. With the range switch S3 in the "High" position, the VCO frequency will increase in 100 Hz. increments. Each of these 100 Hz. increments can be checked in order to determine the overall calibration linearity. Calibration accuracy will usually be within ± 5 Hz. The overall calibration accuracy can usually be improved by shifting the calibration end points between two frequencies other than 5625 & 6625 Hz. Maximum overall accuracy is usually obtained using the upper calibration point of "High" 600 Hz. (approx. 6225 Hz.) with the lower calibration point at "Low" 400 Hz. (approx. 5225 Hz.) which corresponds to input tones of 2725 Hz. and 1725 Hz. respectively. Should accuracy at any two specific frequencies be of prime interest, the calibration end points may be set to these frequencies. R31 adjusts the upper frequency point while R40 adjusts the lower frequency point. When calibrating at points other than "High" 1000 & 000 setting of the shift control, there will be some interaction between the two end point adjustments.

With the calibration described, the space frequency obtained is equal to 2125 Hz. plus the amount of shift indicated on the digital "Shift" knob when the range switch is in the "High" position, and 2125 Hz. minus the digital knob reading when the range switch is in the "Low" position.

5.5.1.7 Channel 2 Mark Calibration

Adjust the Channel 2 mark tone for 2125 Hz. Place the counter input on TP2, and adjust control M-2 (R16) to obtain a VCO frequency of $FL2_{cf}$ plus 2125 Hz. (Approximately 5625 Hz.)

5.5.1.8 Channel 2 Space Frequency Calibration, Model 402

Place the Channel switch S2 in the "2" position, range switch S7 in the "2K" position, and the "Space Freq." digital knob (R1) in the extreme clockwise "000" setting which represents 1000. Attach the counter input to TP3 and adjust control S-2 (R31) until $FL3_{cf}$ plus 3000 Hz. is obtained. (Approx. 6500 Hz.) Then turn the "Space Freq." knob fully counter-clockwise to "000." Adjust control R40 until $FL3_{cf}$ plus 2000 Hz. is obtained at TP3. (Approx. 5500 Hz.)

Calibration linearity should next be checked by

setting R1 at the 100, 200, 300, etc. settings and observing if the VCO frequency at TP3 increases in 100 Hz. increments. With the range switch in the "1K" position this frequency will be $FL3_{cf}$ plus 1000 plus the Space Freq. knob reading in Hz., while "2K" will produce a frequency of $FL3_{cf}$ plus 2000 plus the knob reading in Hz. If the frequency at TP3 changes by more than 5 Hz. between space frequency settings of "1K plus 1000" and "2K plus 000," the value of R2/R2A will have to be matched more closely to the value of R1 to maintain calibration accuracy.

5.5.1.9 Channel 2 Mark Frequency Calibration, Model 402

Except for the controls, the procedure is the same as for the Space frequency calibration. With S2 in the "2" position, the range switch S8 in the "2K" position, and the "Mark Freq." knob at 1000, attach the counter to TP2. Adjust M-2 (R16) for a VCO frequency of $FL2_{cf}$ plus 3000 Hz. Set the "Mark Freq." knob (R6) to "000." Adjust the mark range control R41 until a frequency of $FL2_{cf}$ plus 2000 Hz. is obtained at TP2. If the frequency at TP2 changes by more than 5 Hz. between "Mark Freq." settings of "1K plus 1000" and "2K plus 000," the value of R7 must be more closely matched to the value of R6 if calibration accuracy is to be maintained.

Overall calibration accuracy may be improved as described in section 5.5.1.6 by shifting the calibration end points slightly. Usually the upper calibration point is best set at "2K plus 600" which gives a VCO frequency of $FL3_{cf}$ plus 2600 Hz., and the lower calibration point is best set at "1K plus 600" which gives a VCO frequency 1000 Hz. lower. Should two specific frequencies be of prime interest, the calibration points may be set to these frequencies. In any event, R31 sets the upper point and R40 sets the lower point for the "Space Freq." calibration. Use $FL3_{cf}$ in the calculations and measure the VCO frequency at TP3. Similarly, R16 sets the upper point and R41 sets the lower point for the "Mark Freq." calibration. Use $FL2_{cf}$ in the mark frequency calculations and measure the VCO frequency at TP2.

5.5.1.10 Channel Amplitude and Balance

Place the "Shift" control at "000" on the Model 400. Place both the "Mark Freq." & "Space Freq." settings at 2125 Hz. on the Model 402. Feed a tone of 2125 Hz. into the converter and place the Channel selector in the "2M" position. With a dc voltmeter or oscilloscope connected to TP4 adjust the "M Amp" control (R14) from CCW to CW until the voltage limit is obtained. This saturation level will occur near -13 volts. Reduce the magnitude of this voltage by 0.4 volts. Place the Channel selector in the "2S" position. Adjust the "S Amp" control (R28) to determine the voltage limit of the space channel, which will be in the +13 volt region. Reduce this voltage 0.4 volts below saturation. Place

the Channel selector in the "2" position. The voltage at TP4 will be zero if both the mark and space channels are balanced. If a positive voltage exists at TP4, reduce R28 until balance is obtained. If a negative voltage exists, reduce R14 to obtain balance. The gains of the mark and space amplifiers are now balanced so that a signal occurring in both simultaneously will produce zero output from the detectors. Since the bandwidth characteristics of the filters are identical, Gaussian noise entering these channels simultaneously will tend to cancel and have little effect on the signal voltages being received.

5.5.1.11 Multiplier Balance

Place the M Bal (R69) and the S Bal (R79) controls near their centers of rotation. Set the "Shift" control to "High, 850 Hz." on the 400, and the "Mark Freq." to 2125 Hz. and the "Space Freq." to 2975 Hz. on the Model 402. Place the Channel selector to the "2" position, the Power switch (S5) to CRT, and feed a 2125 Hz. tone into the converter. A vertical trace should appear on the CRT screen. The position, focus, and intensity of this trace may be adjusted as previously described in section 3.3.3. If a trace is not visible, turn the CRT Blanking control (R29) on the Logic Card, 400-200, fully CCW.

While feeding the 2125 Hz. tone into the converter, place the Channel selector to the "2S" position and adjust R69 for minimum vertical display. Then feed a 2975 Hz. tone into the converter, place the Channel selector to the "2M" position and adjust R79 for minimum horizontal display. Repeat this procedure as necessary until only a dot is visible on the screen when nulling each balance control. Return the Channel selector to the "2" position and a vertical trace should appear when the mark frequency of 2125 Hz. is applied, while a horizontal trace should appear when the space frequency of 2975 Hz. is applied. Using these two frequency settings, adjust the vertical and horizontal gain controls on the Monitor Card to provide trace lengths of 34 mm. as described in section 3.3.3.3. If after completing these adjustments the traces are not vertical and horizontal, release the clamp holding the CRT base and rotate the tube to its proper position. Then gently push the CRT face against the cushion within the bezel, and again clamp the base. Turn the high voltage CRT supply off while handling this tube by placing the Power switch in the "On" or "Off" positions.

5.5.2 LOGIC CARD, P. N. 400-200, ADJUSTMENTS

5.5.2.1 Bias Adjustment

Place the front panel Keying switch, S1, to the "Normal" position, the Bias control (R5) on the Model 400 to "0," and the Baud switch, S4 to "50." If an F. S. Tone Keyer capable of being keyed by square wave reversals is available, apply the signal from this keyer to the audio input of the 400.

The square wave reversals may be obtained from a test distributor operating at 50 bauds, or from a square wave function generator operating at a frequency of 25 Hz. This adjustment may be performed at other baud rates, if preferred, as long as the Baud switch setting corresponds to the keying rate of the generator. A baud setting of 45 requires a 22.7 Hz. square wave, while a baud setting of 75 requires a 37.5 Hz. square wave. Connect the vertical input of an oscilloscope to TP5 and adjust the sweep rate to display one keyed square wave across the screen. Carefully set the Bias adjustment (R9) on the Logic Card to produce a duty cycle of exactly 50% on this waveform. If the sweep is triggered by the leading edge of the square wave, a 50% duty cycle is easily observed by alternating between the "Normal" and "Reverse" positions on Keying switch S1, and observing when the mid waveform transition remains stationary.

If an oscilloscope is not available, the 50% duty cycle may be observed on a dc milliammeter connected between J6-1 and J6-2 on the rear panel. Place S1 in the "Standby" position and set the loop current to 60 ma. Then place S1 in the normal and reverse positions. A keyed square wave having 50% duty cycle will cause the meter to read 30 ma. in either of these positions. With S1 in the "Normal" position, adjustment of the Model 400 front panel "Bias" control in a marking direction will increase the meter reading toward 40 ma., while adjustment in a spacing direction will reduce the reading toward 20 ma.

If an F. S. Tone Keyer is not available, the output of the square wave generator may be applied thru a 3.3K ohm resistor to the summing junction within the converter. Connect the output from the generator in series with a 3.3K ohm resistor to terminal #1 on Channel switch S2. (This terminal is located on the rear wafer of S2, contains a red wire, and is adjacent to the side of the cabinet. See figure 9.) Connect the common lead of the generator to ground. Adjust the output to provide a 15 v. p-p square wave, centered on 0 volts. Be certain to remove any signal source from input connector J5, when applying the keyed waveform in this manner. The bias adjustment procedure remains the same as described above.

5.5.2.2 Autostart Level

Observe the voltage between TP6 and ground using a dc meter or oscilloscope. A voltage of approximately 14 v. indicates a carrier within autostart range is present, while 0 v. indicates lack of an autostart signal.

Set the "Shift" control on the Model 400 to "High, 550" and feed a tone of 2675 Hz. into the converter. With the "Channel" switch in the "2" position a horizontal line of maximum length should be obtained. Turn the Autostart control R21 on the Logic card counter-clockwise until 14 v. appears. Normally the autostart bandwidth is set to accept a signal within plus or minus 50 Hz. of the mark or

space tones. Therefore, increase the "Shift" knob reading by 50 Hz. to "600." Turn R21 CW until the voltage at TP6 drops to 0. Slowly turn R21 CCW until 14 v. again appears. The total acceptable autostart range may then be checked by turning the Shift control and noting the frequency range over which 14 v. is present on TP6. When a tone of 2675 Hz. is being fed into the converter and R21 is adjusted as described, the autostart range should extend from a Shift setting of 500 to 600 Hz. which corresponds to ± 50 Hz. from the center of the space frequency. Since both the mark and space channel characteristics are identical, this adjustment will provide autostart operation within 50 Hz. of both the mark and space frequencies. When using a narrow bandwidth input filter, noise energy concentrated within its spectrum may prevent the converter from going to "Standby" when the signal is removed. This condition may be corrected by setting the autostart bandwidth to ± 40 Hz. rather than ± 50 Hz.

For Autostart adjustment of the Model 402, set the "Space Freq." to 2550 Hz. and the "Mark Freq." to 2000 Hz. Feed a 2550 Hz. tone into the Model 402, increase the "Space Freq." knob by 50 Hz. and adjust R21 exactly as described above for the Model 400.

5.5.2.3 CRT Blanking

Set the Shift or Freq. controls as described for autostart adjustment in section 5.5.2.2, and apply a frequency of 2675 Hz. (Model 400) or 2550 Hz. (Model 402) as described. With the "CRT Blanking" control R29 fully CCW adjust the Shift (400) or Space Freq. (402) knobs approximately 55 Hz. higher until the length of the CRT trace is reduced to about 20 mm. Turn R29 fully CW and wait about 2 seconds until the trace extinguishes. Slowly rotate R29 CCW until the trace again appears. If desired, the trace may be left visible for shorter lengths by setting R29 accordingly. However, high noise energy into the mark and space channels from very narrow bandwidth receivers may be sufficient to turn on the display.

5.5.2.4 Antispace Timer

The antispace timer is most easily and accurately calibrated using an electronic timer having start-stop triggering. The timer is used to measure the interval between the start trigger pulse and the stop trigger pulse. The start pulse is obtained from TP5 by triggering on the positive going voltage (+ slope). The stop pulse is available as a negative going voltage (- slope) at U5 pin 1, with S201 in the "On" position. This voltage is also available on the right hand side of R67. (See figure 11.) If a timer is not available, a scope having a calibrated time base and triggered sweep may be used. Triggering is obtained from TP5 with the scope presentation obtained from U5 pin 1.

Feed a mark tone into the 400. Remove the mark, or switch to the space tone, and observe the length of time required for the voltage at U2 pin 1 to drop to zero. This duration will be read directly on the timer, or obtained from the calibrated time base on the scope. The range of adjustment of the Antispace control, R17, should include from 75 to 145 msec. Set R17 to provide a timing interval of 142 ± 2 msec. when switching from mark to space. In order to provide an accurate measurement, maintain the mark tone for at least 2 seconds prior to switching.

The following alternate method of setting the antispace timer may be used when suitable test equipment is not available. Feed the 400 from a tone keyer which is sending a continuous series of "blanks" from a transmitting distributor. (The teleprinter equipment must be using 5 level Baudot code at a 45.45 baud rate.) With the output of the 400 feeding a teleprinter, rotate R17 from its extreme CW position until the red "Stby" indicator flashes and the printer starts to print the character T. Rotate R17 CW again until the printer stops printing T and just idles on the non-printing "Blank" function, with the "Stby" indicator still faintly flashing. If properly adjusted, transmitting a space condition after a continuous marking condition will cause the printer to return to mark without printing any characters.

5.5.2.5 Mark-Hold/Autostart Timer Check

If a start-stop timer is available, connect the start channel to TP5 (- slope) and the stop channel (+ slope) to the anode (right side) of CR7. Place the Keying switch S1 in the "Mark" position. Measure the turn on timing by first feeding a steady space signal into the 400 for 15 seconds, and then switching to a steady mark tone. The timed interval should be $1.3 \pm .3$ seconds. Place S1 in the "Auto" position and repeat the sequence. The interval should be $3.6 \pm .8$ seconds.

The turn off timing is obtained from the same test points by setting the start channel for + slope and the stop channel for - slope. Maintain a steady marking signal for at least 15 seconds before switching to space. The intervals should be in the same range as those given for the turn on condition.

These intervals may be measured less precisely by observing the "Stby" and "Recv" front panel indicators. Turn S201 off. The turn on time will be the duration from the space to mark transition until the "Recv" indicator lights. The turn off time will be the duration from the mark to space transition until the "Stby" indicator lights. Upon completion of this measurement, return S201 to the on position.

NOTE: Antispace switch S201 is included to assist testing of this equipment and to allow defeating the antispace feature should reception of slow speed signals be required. Since it operates on the control logic, a malfunction of S201 could place the converter in a permanent standby condition.

5.5.2.6 Motor Delay Timer

Place S1 in the "Auto" position. Using the same setup as for measuring the Mark-hold/Autostart timer turn off, but with the stop channel connected to U3 pin 4 (right side of R49), measure the interval from the mark to space transition until the timer turns off. This duration can also be checked by plugging a lamp or tty motor into J7 and measuring the time from the mark to space transition until the power at J7 turns off. The interval should be 50 ± 15 seconds.

5.5.2.7 Loop Current Timer

This timer turns off the loop current 5 to 10 seconds after the motor turns off. By observing the time between the power removal at J7 and the loop current falling to zero, the interval may be obtained. This timing cycle may be initiated by placing S1 in the "Mark" position for 5 seconds, and then returning S1 to the "Auto" position.

If precise measurement is desired, connect the start channel (+ slope) of an electronic timer to the cathode of CR11 and the stop channel (- slope) to P2-11 (right side of R63).

FIGURE 8, BOTTOM INTERNAL VIEW OF ELECTROCOM 400

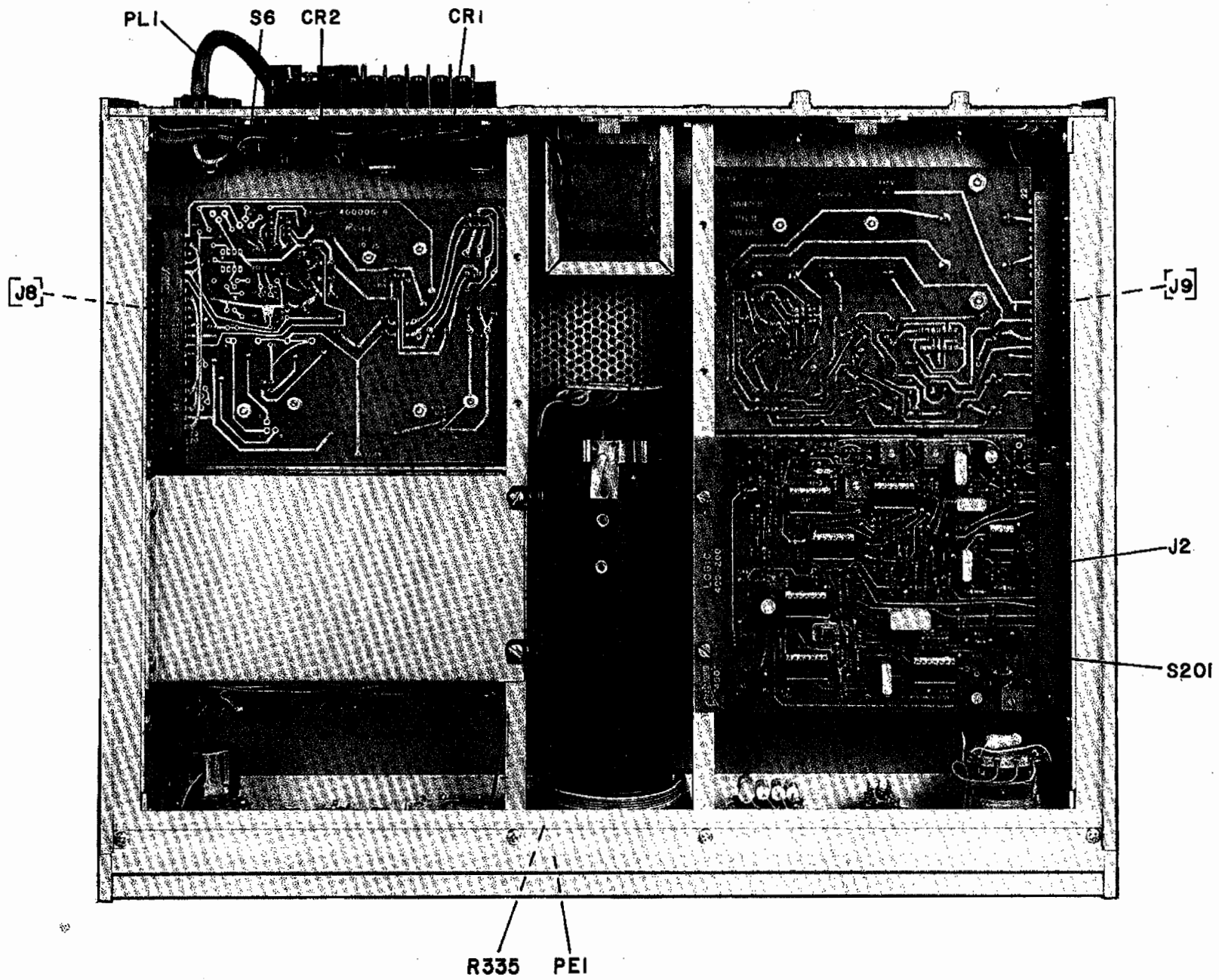
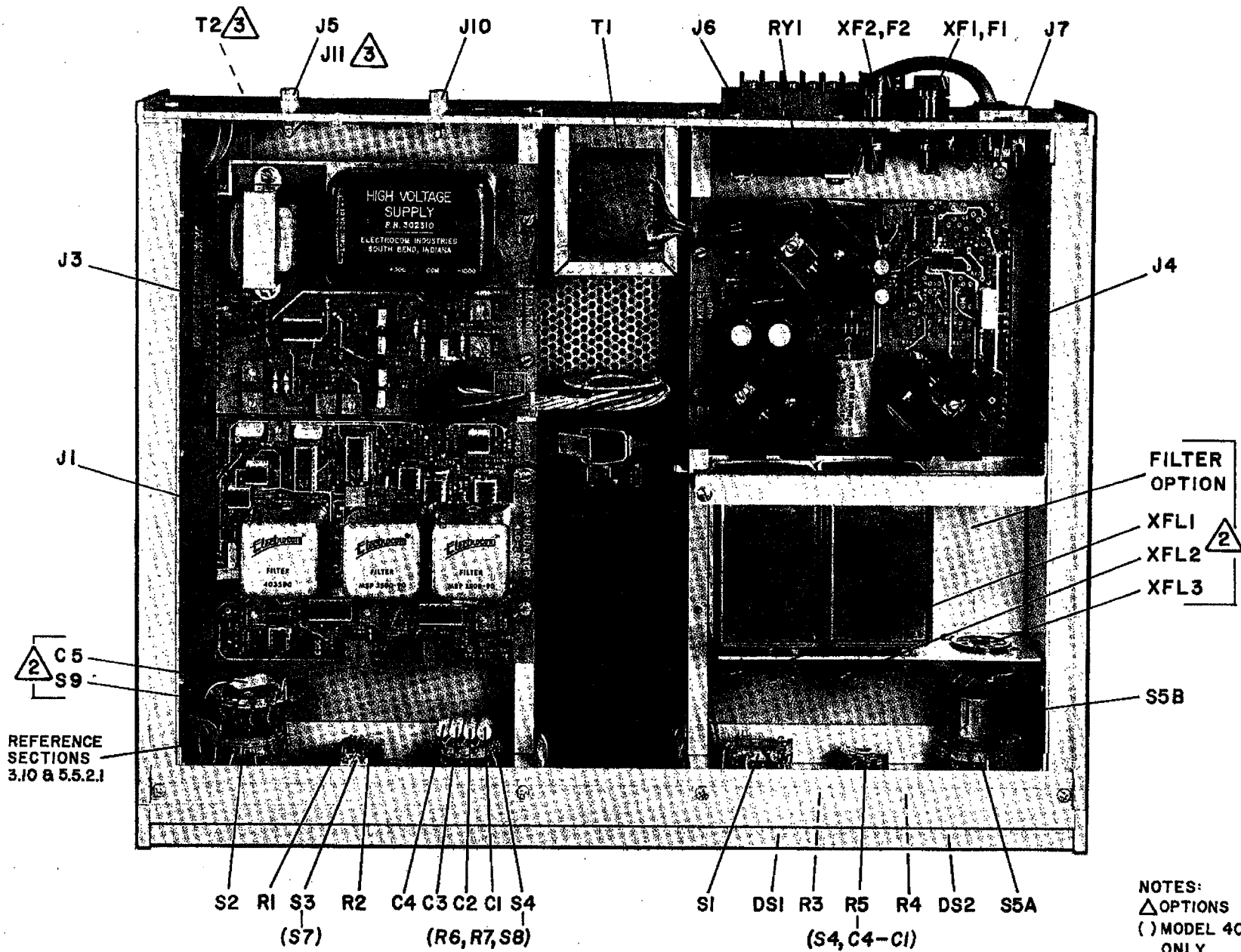


FIGURE 9, TOP INTERNAL VIEW OF ELECTROCOM 400



REFERENCE SECTIONS 3.10 & 5.5.2.1

NOTES:
 Δ OPTIONS
 () MODEL 402 ONLY

SECTION 6, SERVICE PARTS LIST

When ordering service parts from the factory, it is advisable that both the item number and the Electrocom part number be given. This information will assure that the most suitable component is supplied in the event of an engineering change. All of the ¼ and ½ watt resistors described as fixed composition units may be either of the molded or carbon film types.

For simplification of this parts list and legends, all resistors, capacitors, integrated circuits and transistors on the printed circuit cards are numbered 1 through 99. When describing these parts with respect to the complete converter assembly, add the printed circuit card number to the item number. For example: Resistor R5 on the main frame should be described as R5, while R5 on the Demodulator Card 400-100 should be R105, R5 on the Logic

Card 400-200 should be R205, etc. All other item numbers are properly shown. An asterisk (*) after an item number refers to the following notations:

- (*1) Used only on Model 400.
- (*2) Used only on Model 402.
- (*3) Used only with Option #3 (balanced input).
- (*4) Used only with Accessory and Modulator Card options.
- (*5) Used only with Option #2 (input filter).
- (*6) Optional, see schematic diagram.
- (*7) Used only with Options #4 & #5 (polar output).
- (*8) Used only with Option #4.
- (*9) Used only with Option #5.

MAIN FRAME (Schematics 400001, Model 400, and 402001, Model 402)

ITEM	DESCRIPTION	ELECTROCOM PART NO.	ITEM	DESCRIPTION	ELECTROCOM PART NO.
C1	Capacitor, tubular polyester film, .082 mfd., 5%, 100 v.	2238201	R4	Resistor, fixed comp., 560 ohm, 5%, ½ wt.	3131156
C2	Capacitor, tubular polyester film, .047 mfd., 5%, 100 v.	2234701	R5(*1)	Resistor, variable comp., 500K ohm, ½ wt., center detent	3550402
C3	Capacitor, tubular polyester film, .039 mfd., 5%, 100 v.	2233901	R6(*2)	Resistor assembly, same as R1	3711001
C4	Capacitor, tubular polyester film, .039 mfd., 5%, 100 v.	2233901	R7(*2)	Resistor, metal film, ½ wt., as required to match value of R6 within 0.3 ohm. (Supplied only with R6)	
C5(*5)	Capacitor, tubular polyester film, .22 mfd., 10%, 100 v.	2242201	RY1	Relay, optically isolated, 90-240 v., 50-60 Hz., 6 ampere contacts; 3-32 vdc input	454206
CR1	Diode, silicon, 100 piv, type 1N4002	1140021	S1	Switch, rotary phenolic, 6 position with adjustable detent	41021
CR2	Varistor, Metal Oxide, 207 v. peak, 10 joules, ½ wt.	1713001	S2	Switch, rotary phenolic, 6 position, dual wafer	41022
DS1	Light Emitting Diode, Red, T-1¾	1692001	S3(*1)	Switch, miniature toggle, DPDT	422060
DS2	Light Emitting Diode, Green, T-1¾	1692031	S4	Switch, rotary phenolic, 5 position	41024
F1	Fuse, ¾ ampere, 230 v., type 3AG	7110037	S5	Switch, rotary phenolic, 4 pos. with AC toggle	41025
F2	Fuse, ¾ ampere, 230 v., type 3AG	7110019	S6	Switch, slide, 115/230 v. legends, DPDT, slotted actuator	436206
J1	Connector, edge card, 22 position dual	534490	S7(*2)	Switch, miniature toggle, 4PDT	424060
J2	Connector, same as J1	534490	S8(*2)	Switch, miniature toggle, 4PDT	424060
J3	Connector, same as J1	534490	S9(*5)	Switch, rotary phenolic, 2P4 Position	41029
J4	Connector, same as J1	534490	T1	Transformer, power — Primary: 115/230 v., 50-400 Hz. Secondaries: (1) 23 vac, 400 ma., (2) 23 vac, 400 ma., and (3) 110 vac, 70 ma. (Includes plug P401)	624005
J5	Connector, phono jack	533501	T2(*3)	Transformer, audio, 600:600 ohms	610162
J6	Connector, barrier strip, 8 screw terminals	521308	XDS1	Receptacle, LED	548613
J7	Connector, AC receptacle	551558	XDS2	Receptacle, LED	548613
J8(*4)	Connector, edge card, 22 position dual	534490	XF1	Receptacle, Fuse, 3AG	551301
J9(*4)	Connector, same as J8	534490	XF2	Receptacle, Fuse, 3AG	551301
J10	Connector, same as J5	533501	XFL1(*5)	Receptacle, octal	540778
J11(*3)	Connector, barrier strip, 2 screw terminals	521102	XFL2(*5)	Receptacle, octal	540778
P401	Connector, part of T1 assembly		XFL3(*5)	Receptacle, octal	540778
PL1	Plug cordset, plastic, 3 conductor grounding, 6 feet long	577106	—	Knob, bar, ¼" shaft (for controls S1, S2, S4, S5 & R5)	517304
R1	Resistor assembly, potentiometer with integral digital readout, 100±5% ohms, 10 turn wirewound, TC of wire: 20ppm/°C	3711001	—(*5)	Knob, concentric, ¼" shaft (for use with combined controls S2/S9)	517032
R2/R2A	Resistor, metal film, ½ wt., as required to match value of R1 within 0.3 ohm. (Supplied only with R1)		—(*5)	Knob, round, ¼" shaft (for control S9)	515011
R3	Resistor, fixed comp., 560 ohm, 5%, ½ wt.	3131156			

DEMODULATOR CARD, P. N. 400-100
(Schematic 400101)

ITEM	DESCRIPTION	ELECTROCOM PART NO.	ITEM	DESCRIPTION	ELECTROCOM PART NO.
C1	Capacitor, disc ceramic, .05 mfd. $\pm 20\%$, 25 v.	2345001	R21	Resistor, fixed carbon film, 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3221247
C2	Capacitor, disc ceramic, 50 pf. $\pm 10\%$, 100 v.	2405001	R22	Resistor, fixed comp., 200 ohm, 5%, $\frac{1}{4}$ wt.	3121120
C3	Capacitor, disc ceramic, 3.3 pf. $\pm 5\%$, 100 v.	2400301	R23	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
C4	Capacitor, disc ceramic, .05 mfd. $\pm 20\%$, 25 v.	2345001	R24	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
C5	Capacitor, metalized mylar, .10 mfd. $\pm 10\%$, 100 v.	2341001	R25	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
C6	Capacitor, tantalum, 10 mfd. $\pm 20\%$, 10 vdc.	2861001	R26	Resistor, fixed comp., 30K ohm, 5%, $\frac{1}{4}$ wt.	3121330
C7	Capacitor, dipped mica, .0068 mfd. $\pm 5\%$, 100 v.	2126801	R27	Resistor, fixed comp., 5.6K ohm, 5%, $\frac{1}{4}$ wt.	3121256
C8	Capacitor, tantalum, 1.5 mfd. $\pm 10\%$, 25 vdc.	2851501	R28	Resistor, variable cermet, 100K ohm, 10%, $\frac{1}{2}$ wt.	3641001
C9	Capacitor, metalized mylar, .10 mfd. $\pm 10\%$, 100 v.	2341001	R29	Resistor, fixed comp., 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3121247
C10	Capacitor, tantalum, 10 mfd. $\pm 20\%$, 10 vdc.	2861001	R30	Resistor, fixed metal film, 15.0K ohm, 1% $\frac{1}{4}$ wt.	3312150
C11	Capacitor, dipped mica, .0068 mfd. $\pm 5\%$, 100 v.	2126801	R31	Resistor, variable ww., 5K ohm, 5%, 1 wt., 25 turns	3725001
C12	Capacitor, tantalum, 1.5 mfd. $\pm 10\%$, 25 vdc.	2851501	R32	Resistor, fixed carbon film, 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3221247
C13	Capacitor, tantalum, 1.5 mfd. $\pm 10\%$, 25 vdc.	2851501	R33	Resistor, fixed metal film, 15.0K ohm, 1%, $\frac{1}{4}$ wt.	3312150
C14	Capacitor, tantalum, 1.5 mfd. $\pm 10\%$, 25 vdc.	2851501	R34	Resistor, variable ww., 20K ohm, 5%, 1 wt., 25 turns	3732001
C15	Capacitor, disc ceramic, 20 pf. $\pm 5\%$, 100 v.	2402001	R34A	Resistor, fixed metal film, 200K ohm, 1%, $\frac{1}{2}$ wt.	3313200
C16	Capacitor, metalized mylar, .10 mfd. $\pm 10\%$, 100 v.	2341001	R35	Resistor, fixed carbon film, 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3121247
C17	Capacitor, disc ceramic, 20 pf. $\pm 5\%$, 100 v.	2402001	R36	Resistor, fixed comp., 200 ohm, 5%, $\frac{1}{4}$ wt.	3121120
C18	Capacitor, metalized mylar, .10 mfd. $\pm 10\%$, 100 v.	2341001	R37	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
C19	Capacitor, disc ceramic, 220 pf. $\pm 10\%$, 1 Kv.	2412201	R38	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
C20	Capacitor, metalized mylar, .056 mfd. $\pm 10\%$, 100 v.	2335601	R39	Resistor, fixed metal film, 2.61K ohm, 1%, $\frac{1}{4}$ wt.	3311261
C21	Capacitor, disc ceramic, .10 mfd. $\pm 20\%$, 25 v.	2441001	R40	Resistor, variable ww., 1K ohm, 5%, 1 wt., 25 turns	3721001
C22	Capacitor, disc ceramic, .10 mfd. $\pm 20\%$, 25 v.	2441001	R41(*2)	Resistor, variable ww., 1K ohm, 5%, 1 wt., 25 turns	3721001
CR1 thru CR10	Diode, silicon, 10 ma., 75 piv. (type 1N4148)	1141481	R42(*2)	Resistor, fixed metal film, 2.61K ohm, 1%, $\frac{1}{4}$ wt.	3311261
CR11(*5)	Diode, silicon, same as CR1	1141481	R43	Resistor, fixed comp., 750 ohm, 5%, $\frac{1}{4}$ wt.	3121175
CR12(*5)	Diode, silicon, same as CR1	1141481	R44	Resistor, fixed comp., 15K ohm, 5%, $\frac{1}{4}$ wt.	3121315
FL1	Filter, low pass, 3 db. at 3500 Hz.	403500	R45	Resistor, fixed comp., 680 ohm, 5%, $\frac{1}{4}$ wt.	3121168
FL2	Filter, bandpass, 95 ± 10 Hz. bw at 3 db., 3500 Hz. ctr. freq.	MBP350090	R46	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
FL3	Filter, bandpass, 95 ± 10 Hz. bw at 3 db., 3500 Hz. ctr. freq.	MBP350090	R47	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
R1	Resistor, fixed comp., 680 ohm, 5%, $\frac{1}{2}$ wt.	3131168	R48	Resistor, fixed comp., 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3121247
R2	Resistor, fixed comp., 3.3K ohm, 5%, $\frac{1}{4}$ wt.	3121233	R49	Resistor, fixed comp., 750 ohm, 5%, $\frac{1}{4}$ wt.	3121175
R3	Resistor, fixed comp., 100 ohm, 5%, $\frac{1}{4}$ wt.	3121110	R50	Resistor, fixed comp., 15K ohm, 5%, $\frac{1}{4}$ wt.	3121315
R4	Resistor, fixed comp., 100 ohm, 5%, $\frac{1}{4}$ wt.	3121110	R51	Resistor, fixed comp., 680 ohm, 5%, $\frac{1}{4}$ wt.	3121168
R5	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310	R52	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
R6	Resistor, fixed comp., 24K ohm, 5%, $\frac{1}{4}$ wt.	3121324	R53	Resistor, fixed comp., 10K ohm, 5%, $\frac{1}{4}$ wt.	3121310
R7	Resistor, variable cermet, 5K ohm, 10%, $\frac{1}{2}$ wt.	3625001	R54	Resistor, fixed comp., 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3121247
R8	Resistor, fixed comp., 24K ohm, 5%, $\frac{1}{4}$ wt.	3121324	R55	Resistor, fixed metal film, 20.0K ohm, 1%, $\frac{1}{4}$ wt.	3312200
R9	Resistor, fixed comp., 100 ohm, 5%, $\frac{1}{4}$ wt.	3121110	R56	Resistor, fixed comp., 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3121247
R10	Resistor, fixed comp., 100 ohm, 5%, $\frac{1}{4}$ wt.	3121110	R57	Resistor, fixed metal film, 20.0K ohm, 1%, $\frac{1}{4}$ wt.	3312200
R11	Resistor, fixed comp., 1.5K ohm, 5%, $\frac{1}{4}$ wt.	3121215	R58	Resistor, fixed metal film, 10.0K ohm, 1%, $\frac{1}{4}$ wt.	3312100
R12	Resistor, fixed comp., 30K ohm, 5%, $\frac{1}{4}$ wt.	3121330	R59	Resistor, fixed metal film, 20.0K ohm, 1%, $\frac{1}{4}$ wt.	3312200
R13	Resistor, fixed comp., 5.6K ohm, 5%, $\frac{1}{4}$ wt.	3121256	R60	Resistor, fixed metal film, 20.0K ohm, 1%, $\frac{1}{4}$ wt.	3312200
R14	Resistor, variable cermet, 100K ohm, 10%, $\frac{1}{2}$ wt.	3641001	R61	Resistor, fixed comp., 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3121247
R15	Resistor, fixed comp., 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3121247	R62	Resistor, fixed metal film, 20.0K ohm, 1%, $\frac{1}{4}$ wt.	3312200
R16	Resistor, variable ww., 5K ohm, 5%, 1 wt., 25 turns	3725001	R63	Resistor, fixed metal film, 10.0K ohm, 1%, $\frac{1}{4}$ wt.	3312100
R17(*1)	Resistor, fixed metal film, 19.1K ohm, 1%, $\frac{1}{4}$ wt.	3312191	R64	Resistor, fixed metal film, 20.0K ohm, 1%, $\frac{1}{4}$ wt.	3312200
R17(*2)	Resistor, fixed metal film, 15.0K ohm, 1%, $\frac{1}{4}$ wt.	3312150	R65	Resistor, fixed comp., 22K ohm, 5%, $\frac{1}{4}$ wt.	3121322
R18	Resistor, fixed carbon film, 4.7K ohm, 5%, $\frac{1}{4}$ wt.	3221247			
R19	Resistor, variable ww., 20K ohm, 5%, 1 wt., 25 turns	3732001			
R19A	Resistor, fixed metal film, 200K ohm, 1%, $\frac{1}{4}$ wt.	3313200			
R20	Resistor, fixed metal film, 15.0K ohm, 1%, $\frac{1}{4}$ wt.	3312150			

Demodulator Card, continued

ITEM	DESCRIPTION	ELECTROCOM PART NO.	ITEM	DESCRIPTION	ELECTROCOM PART NO.
R66	Resistor, fixed comp., 2.7K ohm, 5%, ¼ wt.	3121227	R88(*5)	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310
R67	Resistor, fixed comp., 100 ohm, 5%, ¼ wt.	3121110	R89(*5)	Resistor, fixed comp., 620 ohm, 5%, ¼ wt.	3121162
R68	Resistor, fixed comp., 2.2K ohm, 5%, ¼ wt.	3121222	R90(*5)	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310
R69	Resistor, variable cermet, 20K ohm, 10%, ½ wt.	3632001	R91(*5)	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
R70	Resistor, fixed comp., 100K ohm, 5%, ¼ wt.	3121410	R92(*5)	Resistor, fixed comp., 560 ohm, 5%, ¼ wt.	3121156
R71	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310	R93(*6)	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
R72	Resistor, fixed comp., 22K ohm, 5%, ¼ wt.	3121322	RT1	Thermistor, 130 ohm, 10% at 25°C	3811301
R73	Resistor, fixed comp., 30K ohm, 5%, ¼ wt.	3121330	RT2	Thermistor, 130 ohm, 10% at 25°C	3811301
R74	Resistor, fixed comp., 24K ohm, 5%, ¼ wt.	3121324	U1	Integrated circuit, operational amplifier, 8 pin mini-dip type 1709CP-1	1417091
R75	Resistor, fixed comp., 24K ohm, 5%, ¼ wt.	3121324	U2	Integrated circuit, monolithic function generator, type 2206CP	1422061
R76	Resistor, fixed comp., 300K ohm, 5%, ¼ wt.	3121430	U3	Integrated circuit, type 2206CP	1422061
R77	Resistor, fixed comp., 300K ohm, 5%, ¼ wt.	3121430	U4	Integrated circuit, operational amplifier, 8 pin mini-dip type 741CN	1407411
R78	Resistor, variable cermet, 20K ohm, 10%, ½ wt.	3632001	U5	Integrated circuit, type 741CN	1407411
R79	Resistor, fixed comp., 100K ohm, 5%, ¼ wt.	3121410	U6	Integrated circuit, type 741CN	1407411
R80	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310	U7	Integrated circuit, type 741CN	1407411
R81	Resistor, fixed comp., 22K ohm, 5%, ¼ wt.	3121322	U8	Integrated circuit, operational multiplier, type 2208CP	1422081
R82	Resistor, fixed comp., 30K ohm, 5%, ¼ wt.	3121330	U9	Integrated circuit, operational multiplier, type 2208CP	1422081
R83	Resistor, fixed comp., 30K ohm, 5%, ¼ wt.	3121324	U10	Integrated circuit, type 741CN	1407411
R84	Resistor, fixed comp., 24K ohm, 5%, ¼ wt.	3121324	U11(*5)	Integrated circuit, type 741CN	1407411
R85	Resistor, fixed comp., 24K ohm, 5%, ¼ wt.	3121324			
R86	Resistor, fixed comp., 300K ohm, 5%, ¼ wt.	3121430			
R87	Resistor, fixed comp., 43K ohm, 5%, ¼ wt.	3121343			

**LOGIC CARD, P. N. 400-200
(Schematic 400201)**

ITEM	DESCRIPTION	ELECTROCOM PART NO.	ITEM	DESCRIPTION	ELECTROCOM PART NO.
C1	Capacitor, metalized mylar, .12 mfd. ±10%, 100 v.	2341201	Q4	Transistor, silicon, NPN (type 2N3569)	1535691
C2	Capacitor, metalized mylar, .68 mfd. ±10%, 100 v.	2346801	R1	Resistor, fixed comp., 13K ohm, 5%, ¼ wt.	3121313
C3	Capacitor, tantalum, 4.7 mfd. ±10%, 20 v.	2854701	R2	Resistor, fixed comp., 13K ohm, 5%, ¼ wt.	3121313
C4	Capacitor, tantalum, 4.7 mfd. ±10%, 20 v.	2854701	R3	Resistor, fixed comp., 27K ohm, 5%, ¼ wt.	3121327
C5	Capacitor, metalized mylar, .22 mfd. ±10%, 100 v.	2342201	R4	Resistor, fixed comp., 470 ohm, 5%, ¼ wt.	3121147
C6	Capacitor, metalized mylar, .22 mfd. ±10%, 100 v.	2342201	R5	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
C7	Capacitor, electrolytic, 10 mfd. -10+100% 35 v.	2561001	R6	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
C8	Capacitor, tantalum, 1.5 mfd. ±10%, 25 v.	2851501	R7	Resistor, fixed comp., 2.2Megohm, 5%, ¼ wt.	3121522
C9	Capacitor, tantalum, 47 mfd. ±10%, 10 v.	2864701	R8	Resistor, fixed comp., 1.5Megohm, 5%, ¼ wt.	3121515
C10	Capacitor, tantalum, 22 mfd. ±20%, 16 v.	2862201	R9	Resistor, variable cermet, 500K ohm, 10%, ½ wt.	3645001
C11	Capacitor, electrolytic, 50 mfd. -10+100%, 35 v.	2565001	R10(*1)	Resistor, fixed comp., 1.2Megohm, 5%, ¼ wt.	3121512
C12	Capacitor, metalized mylar, .12 mfd. ±10%, 100 v.	2341201	R10(*2)	Resistor, fixed comp., 1.5Megohm, 5%, ¼ wt.	3121515
C13	Capacitor, electrolytic, 10 mfd. -10+100% 35 v.	2561001	R11	Resistor, fixed comp., 2.2Megohm, 5%, ¼ wt.	3121522
C14	Capacitor, disc ceramic, .10 mfd. ±20%, 25 v.	2441001	R12	Resistor, fixed comp., 10 Megohm, 10%, ¼ wt.	3122610
C15(*6)	Capacitor, disc ceramic, .01 mfd. ±20%, 16 v.	2431002	R13	Resistor, fixed comp., 750K ohm, 5%, ¼ wt.	3121475
CR8	Diode, silicon, 10 ma., 75 piv (type 1N4148)	1141481	R14	Resistor, fixed comp., 1.5Megohm, 5%, ¼ wt.	3121515
CR9	Diode, silicon, 100 piv. (type 1N4002)	1140021	R15	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310
CR10	Diode, silicon, same as CR1	1141481	R16	Resistor, fixed comp., 620K ohm, 5%, ¼ wt.	3121462
CR11	Diode, silicon, same as CR9	1140021	R17	Resistor, variable cermet, 100K ohm, 10%, ½ wt.	3641001
CR12(*6)	Diode, silicon, same as CR1	1141481	R18	Resistor, fixed comp., 75K ohm, 5%, ¼ wt.	3121375
CR13(*6)	Diode, silicon, same as CR1	1141481	R19	Resistor, fixed comp., 2.2Megohm, 5%, ¼ wt.	3121522
Q1	Transistor, silicon, NPN (type 2N3569)	1535691	R20	Resistor, fixed comp., 4.7Megohm, 5%, ¼ wt.	3121547
Q2	Transistor, silicon, NPN (type 2N3569)	1535691	R21	Resistor, variable cermet, 100K ohm, 10%, ½ wt.	3641001
Q3	Transistor, silicon, NPN (type 2N3569)	1535691	R22	Resistor, fixed comp., 750K ohm, 5%, ¼ wt.	3121475
			R23	Resistor, fixed comp., 4.7K ohm, 5%, ¼ wt.	3121247
			R24	Resistor, fixed comp., 100K ohm, 5%, ¼ wt.	3121410
			R25	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
			R26	Resistor, fixed comp., 22 Megohm, 10%, ¼ wt.	3122622
			R27	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347

Logic Card, continued

ITEM	DESCRIPTION	ELECTROCOM PART NO.	ITEM	DESCRIPTION	ELECTROCOM PART NO.
R28	Resistor, fixed comp., 22 Megohm, 10%, 1/4 wt.	3122622	R54	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347
R29	Resistor, variable cermet, 100K ohm, 10%, 1/2 wt.	3641001	R55	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347
R30	Resistor, fixed comp., 750K ohm, 5%, 1/4 wt.	3121475	R56	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347
R31	Resistor, fixed comp., 2.2K ohm, 5%, 1/4 wt.	3121222	R57	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347
R32	Resistor, fixed comp., 100K ohm, 5%, 1/4 wt.	3121410	R58	Resistor, fixed comp., 18K ohm, 5%, 1/4 wt.	3121318
R33	Resistor, fixed comp., 750K ohm, 5%, 1/4 wt.	3121475	R59	Resistor, fixed comp., 18K ohm, 5%, 1/4 wt.	3121318
R34	Resistor, fixed comp., 1.5Megohm, 5%, 1/4 wt.	3121515	R60	Resistor, fixed comp., 1.0Megohm, 5%, 1/4 wt.	3121510
R35	Resistor, fixed comp., 4.7Megohm, 5%, 1/4 wt.	3121547	R61	Resistor, fixed comp., 18K ohm, 5%, 1/4 wt.	3121318
R36	Resistor, fixed comp., 10K ohm, 5%, 1/4 wt.	3121310	R62	Resistor, fixed comp., 18K ohm, 5%, 1/4 wt.	3121318
R37	Resistor, fixed comp., 100K ohm, 5%, 1/4 wt.	3121410	R63	Resistor, fixed comp., 22K ohm, 5%, 1/4 wt.	3121322
R38	Resistor, fixed comp., 750K ohm, 5%, 1/4 wt.	3121475	R64	Resistor, fixed comp., 1.0K ohm, 5%, 1/4 wt.	3121210
R39	Resistor, fixed comp., 4.7Megohm, 5%, 1/4 wt.	3121547	R65(*6)	Resistor, fixed comp., 3.3K ohm, 5%, 1/4 wt.	3121233
R40	Resistor, fixed comp., 10K ohm, 5%, 1/4 wt.	3121310	R66(*6)	Not Used	
R41	Resistor, fixed comp., 33 ohm, 5%, 1/4 wt.	3121033	R67(*6)	Resistor, fixed comp., 100K ohm, 5%, 1/4 wt.	3121410
R42	Resistor, fixed comp., 2.2Megohm, 5%, 1/4 wt.	3121522	R68(*6)	Resistor, fixed comp., 100K ohm, 5%, 1/4 wt.	3121410
R43	Resistor, fixed comp., 18K ohm, 5%, 1/4 wt.	3121318	S201	Switch, miniature slide, SPDT	431201
R44	Resistor, fixed comp., 2.2Megohm, 5%, 1/4 wt.	3121522	U1	Integrated circuit, amplifier, type 741CN	1407411
R45	Resistor, fixed comp., 10K ohm, 5%, 1/4 wt.	3121310	U2	Integrated circuit, quad amplifier, type LM3900N	1439001
R46	Resistor, fixed comp., 1.0Megohm, 5%, 1/4 wt.	3121510	U3	Integrated circuit, quad amplifier, type LM3900N	1439001
R47	Resistor, fixed comp., 1.0Megohm, 5%, 1/4 wt.	3121510	U4	Integrated circuit, quad 2-NAND gate, type 4011CN	1440111
R48	Resistor, fixed comp., 1.5Megohm, 5%, 1/4 wt.	3121515	U5	Integrated circuit, triple 3-NAND gate, type 4023CN	1440231
R49	Resistor, fixed comp., 2.2Megohm, 5%, 1/4 wt.	3121522	U6	Integrated circuit, quad 2-NAND gate, type 4011CN	1440111
R50	Resistor, fixed comp., 15K ohm, 5%, 1/4 wt.	3121315	U7	Integrated circuit, quad 2-NAND gate, type 4011CN	1440111
R51	Resistor, fixed comp., 6.8K ohm, 5%, 1/4 wt.	3121268			
R52	Resistor, fixed comp., 22K ohm, 5%, 1/4 wt.	3121322			
R53	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347			

MONITOR CARD, P. N. 400-300
(Schematic 400301)

ITEM	DESCRIPTION	ELECTROCOM PART NO.	ITEM	DESCRIPTION	ELECTROCOM PART NO.
CR1	Diode, silicon, 100 piv. (type 1N4002)	1140021	R16	Resistor, fixed comp., 6.8K ohm, 5%, 1/4 wt.	3121268
CRT	Cathode Ray Tube, type 2BP1	2BP1	R17	Resistor, variable cermet, 10K ohm, 10%, 1/2 wt.	3631001
J301	Connector, receptacle, 12 pin PC mounting	530264	R18	Resistor, fixed comp., 3.0K ohm, 5%, 1/4 wt.	3121230
OC1	Optical coupler, 1500 vdc isolation, (type 4N27)	1400271	R19	Resistor, fixed comp., 15K ohm, 5%, 1/4 wt.	3121230
P301	Connector, plug assembly with leads attached, 12 pin	400009	R20	Resistor, fixed comp., 15K ohm, 5%, 1/4 wt.	3121315
PE1	Photocell, CdS, 500K ±33% at 2 fc, T0-18	3941001	R21	Resistor, fixed comp., 150K ohm, 5%, 1/4 wt.	3121415
PS301	Power supply, ultrasonic, 30 vdc input; 300 ±10%, -1000 ±10% vdc output	302310	R22	Resistor, fixed comp., 240K ohm, 5%, 1/4 wt.	3121424
Q1 thru Q5	Transistor, silicon, NPN, 350 vdc (type 2N6177)	1561112	R23	Resistor, fixed comp., 240K ohm, 5%, 1/4 wt.	3121424
Q6	Transistor, silicon, NPN, 40 vdc (type 2N3569)	1535691	R24	Resistor, fixed comp., 240K ohm, 5%, 1/4 wt.	3121424
R1	Resistor, variable cermet, 10K ohm, 10%, 1/2 wt.	3631001	R25	Resistor, fixed comp., 240K ohm, 5%, 1/4 wt.	3121424
R2	Resistor, fixed comp., 3.0K ohm, 5%, 1/4 wt.	3121230	R26	Resistor, variable cermet, 200K ohm, 10%, 1/2 wt.	3642001
R3	Resistor, fixed comp., 220K ohm, 5%, 1/4 wt.	3121422	R27	Resistor, fixed comp., 180K ohm, 5%, 1/4 wt.	3121418
R4	Resistor, fixed comp., 220K ohm, 5%, 1/4 wt.	3121422	R28	Resistor, fixed comp., 240K ohm, 5%, 1/4 wt.	3121424
R5	Resistor, fixed comp., 10K ohm, 5%, 1/4 wt.	3121310	R29	Resistor, fixed comp., 6.8K ohm, 5%, 1/4 wt.	3121268
R6	Resistor, fixed comp., 10K ohm, 5%, 1/4 wt.	3121310	R30	Resistor, variable cermet, 200K ohm, 10%, 1/2 wt.	3642001
R7	Resistor, fixed comp., 2.4K ohm, 5%, 1/4 wt.	3121224	R31	Resistor, fixed comp., 300K ohm, 5%, 1/4 wt.	3121430
R8	Resistor, variable cermet, 1.0K ohm, 10%, 1/2 wt.	3621001	R32	Resistor, fixed comp., 100K ohm, 5%, 1/4 wt.	3121410
R9	Resistor, fixed comp., 2.4K ohm, 5%, 1/4 wt.	3121224	R33	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347
R10	Resistor, fixed comp., 2.4K ohm, 5%, 1/4 wt.	3121224	R34	Resistor, fixed comp., 680 ohm, 5%, 1/2 wt.	3131168
R11	Resistor, variable cermet, 1.0K ohm, 10%, 1/2 wt.	3621001	R35	Resistor, fixed comp., 100K ohm, 10%, 1/4 wt.	3122410
R12	Resistor, fixed comp., 2.4K ohm, 5%, 1/4 wt.	3121224	T301	Transformer, filament, 115/6.3 vac, 6 a.	642981
R13	Resistor, fixed comp., 220K ohm, 5%, 1/4 wt.	3121422	U1	Integrated circuit, transistor array, type 3046N	1430461
R14	Resistor, fixed comp., 220K ohm, 5%, 1/4 wt.	3121422	XCRT	Receptacle, Cathode Ray Tube, 12 pin small shell duodecal	543012
R15	Resistor, fixed comp., 6.8K ohm, 5%, 1/4 wt.	3121268	XPE	Receptacle, photocell	548629

POWER/KEYER CARD, P. N. 400-400
(Schematic 400401)

ITEM	DESCRIPTION	ELECTROCOM PART NO.	ITEM	DESCRIPTION	ELECTROCOM PART NO.
C1	Capacitor, electrolytic, 250 mfd., -10+100%, 50 v.	2572501	R6	Resistor, fixed comp., 3.3K ohm, 5%, ¼ wt.	3121233
C2	Capacitor, electrolytic, 250 mfd., -10+100%, 50 v.	2572501	R7	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310
C3	Capacitor, electrolytic, 50 mfd., -10+100%, 35 v.	2565001	R8	Resistor, fixed comp., 1.5K ohm, 5%, ¼ wt.	3121215
C4	Capacitor, electrolytic, 50 mfd., -10+100%, 35 v.	2565001	R9	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
C5	Capacitor, electrolytic, 50 mfd., -10+100%, 250 v.	2665001	R10	Resistor, fixed comp., 82 ohm, 5%, ½ wt.	3131082
C6	Capacitor, disc ceramic, .01 mfd., ±20%, 16 v.	2431002	R11	Resistor, fixed comp., 2.2K ohm, 5%, ¼ wt.	3121222
C7	Capacitor, disc ceramic, .002 mfd., ±20%, 1 Kv.	2422001	R12	Resistor, fixed comp., 24K ohm, 5%, ¼ wt.	3121324
C8	Capacitor, metalized mylar, 0.10 mfd., ±20%, 400 v.	2341002	R13	Resistor, fixed comp., 2.2K ohm, 5%, ¼ wt.	3121222
C9(*7)	Capacitor, disc ceramic, .01 mfd., ±20%, 16 v.	2431002	R14	Resistor, fixed comp., 3.3K ohm, 5%, ¼ wt.	3121233
CR1	Diode assembly, silicon, bridge, 1 a., 200 piv	1812001	R15(*6)	Resistor, fixed comp., 2.4K ohm, 5%, ¼ wt.	3121224
CR2	Diode assembly, silicon, bridge, 1 a., 200 piv	1812001	R16(*7)	Resistor, fixed comp., 100K ohm, 5%, ¼ wt.	3121410
CR3	Diode assembly, silicon, bridge, 1 a., 600 piv	1816001	R17(*8)	Resistor, fixed comp., 13K ohm, 5%, ¼ wt.	3121313
CR4	Diode, silicon, 1 a., 100 piv	1140021		NOTE: When this resistor is installed, R263 (Logic card, R63) must be changed to 13K ohm, 5%, ¼ wt.	3121313
CR5	Diode, silicon, 1 a., 100 piv	1140021	R18(*7)	Resistor, variable cermet, 10K ohm, 10%, ½ wt.	3631001
CR6	Diode, silicon, 10 ma., 75 piv	1141481	R19(*7)	Resistor, fixed comp., 3.3K ohm, 5%, ¼ wt.	3121233
CR7(*7)	Diode, silicon, 10 ma., 75 piv	1141481	R20(*7)	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310
J401	Connector, receptacle, 6 pin PC mounting	530258	R21(*7)	Resistor, fixed comp., 1.5K ohm, 5%, ¼ wt.	3121215
Q1	Transistor, silicon power, 500 v. (TI type TIP 50)	1500501	R22(*7)	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
Q2(*7)	Transistor, silicon power, 500 v. (TI type TIP 50)	1500501	R23(*7)	Resistor, fixed comp., 82 ohm, 5%, ½ wt.	3131082
Q3(*7)	Transistor, silicon, NPN (type 2N3569)	1535691	R24(*8)	Resistor assembly, fixed ww., 2.5K ohm, 10 wt.	3491225
Q4(*7)	Transistor, silicon, NPN (type 2N3569)	1535691	R25(*8)	Resistor assembly, fixed ww., 2.5K ohm, 10 wt.	3491225
Q5(*9)	Transistor, silicon, PNP (MPSA-92)	1500921	R26(*7)	Resistor, fixed comp., 100K ohm, 5%, ¼ wt.	3121410
Q6(*9)	Transistor, silicon, NPN (MPSA-42)	1500421	R27(*9)	Resistor, fixed comp., 22K ohm, 5%, ¼ wt.	3121322
Q7(*9)	Transistor, silicon, PNP (MPSA-92)	1500921	R28(*9)	Resistor, fixed comp., 56K ohm, 5%, ½ wt.	3131356
Q8(*9)	Transistor, silicon, NPN (MPSA-42)	1500421	R29(*9)	Resistor, fixed comp., 100K ohm, 5%, ¼ wt.	3121410
R1	Resistor, fixed comp., 680 ohm, 5%, ½ wt.	3131168	R30(*9)	Resistor, fixed comp., 22K ohm, 5%, ¼ wt.	3121322
R2	Resistor, fixed comp., 100K ohm, 10%, 1 wt.	3142410	R31(*9)	Resistor, fixed comp., 56K ohm, 5%, ½ wt.	3131356
R3	Resistor, fixed comp., 100 ohm, 10%, 1 wt.	3142110	R32(*9)	Resistor, fixed comp., 100K ohm, 5%, ¼ wt.	3121410
R4	Resistor, fixed comp., 1K ohm, 5%, ¼ wt.	3121210	U1	Integrated circuit, 3 terminal regulator, 15 ±.6 v. (type 7815)	1478151
R5	Resistor, variable cermet, 10K ohm, 10%, ½ wt.	3631001	U2	Integrated circuit, 3 terminal regulator, 15 ±.6 v. (type 7815)	1478151
			U3	Integrated circuit, operational amplifier (mini-dip), type 741CN	1407411
			U4	Integrated circuit, type 741CN	1407411
			U5(*7)	Integrated circuit, type 741CN	1407411

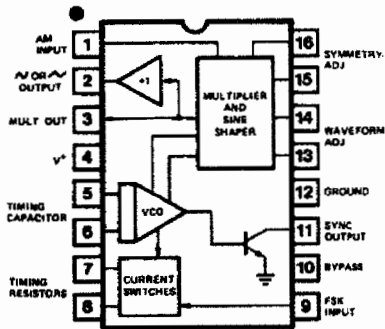
NOTE: Space has been allowed on the Power/Keyer card, p.n. 400-400, for mounting Metal Oxide Varistors across the three secondary windings of power transformer T1. In normal operating environments these devices are not necessary. However, if the equipment is operated from power mains that contain high transient voltages or frequent static discharges, installation of these MOV's may reduce semiconductor failures.

The location of these devices is shown in Figure 13 as CR8, CR9 and CR10. Recommended MOV's are General Electric part number V47ZA7 (Electrocom p.n. 1703001) for CR8 & CR9, and G.E. p.n. V130LA10A (Electrocom p.n. 1713001) for CR10.

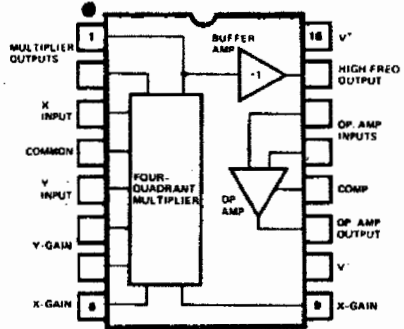
SECTION 7

**SCHEMATICS
AND
CARD LAYOUTS**

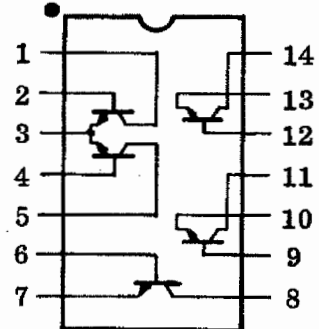
SEMICONDUCTOR PIN ARRANGEMENTS



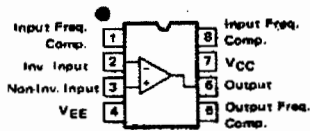
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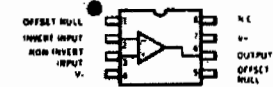
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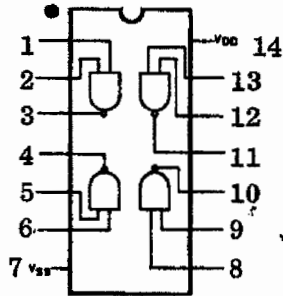
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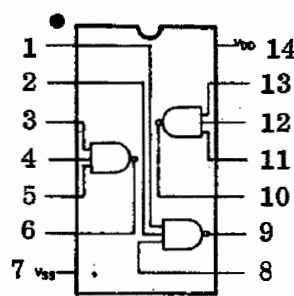
1709-CP1



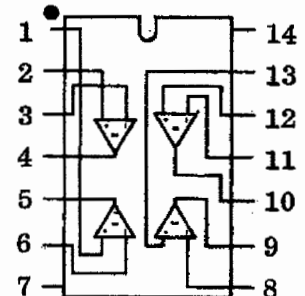
741C



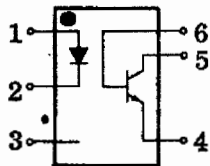
4011AE



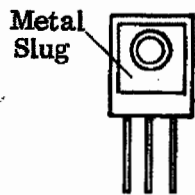
4023AE



LM3900



4N27



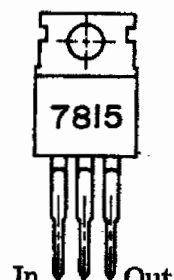
C B E

2N6177



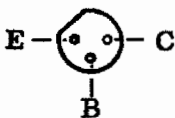
B C E

TIP 50



In C Out

7815



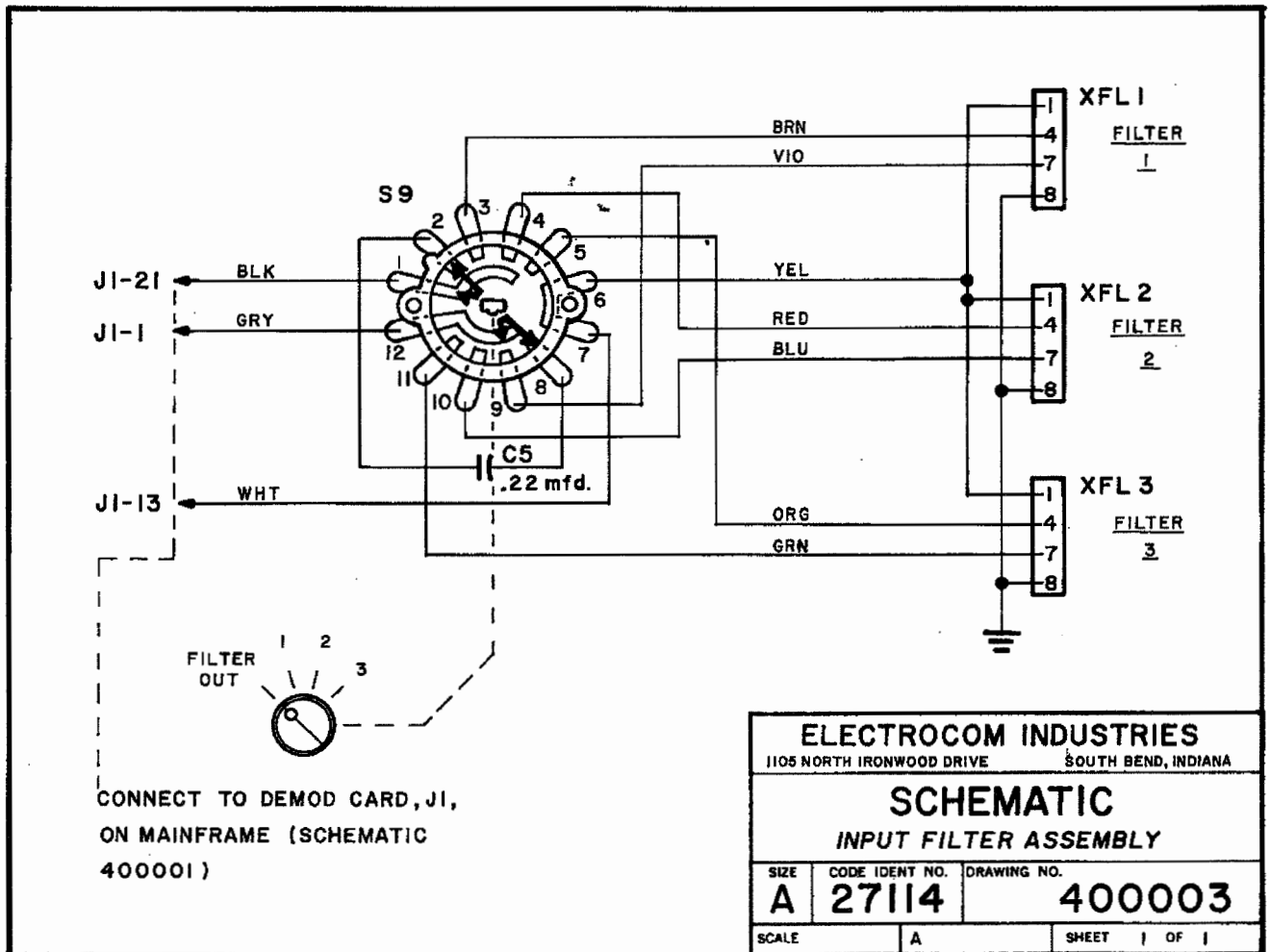
2N3569

NOTE: Top view shown on all devices

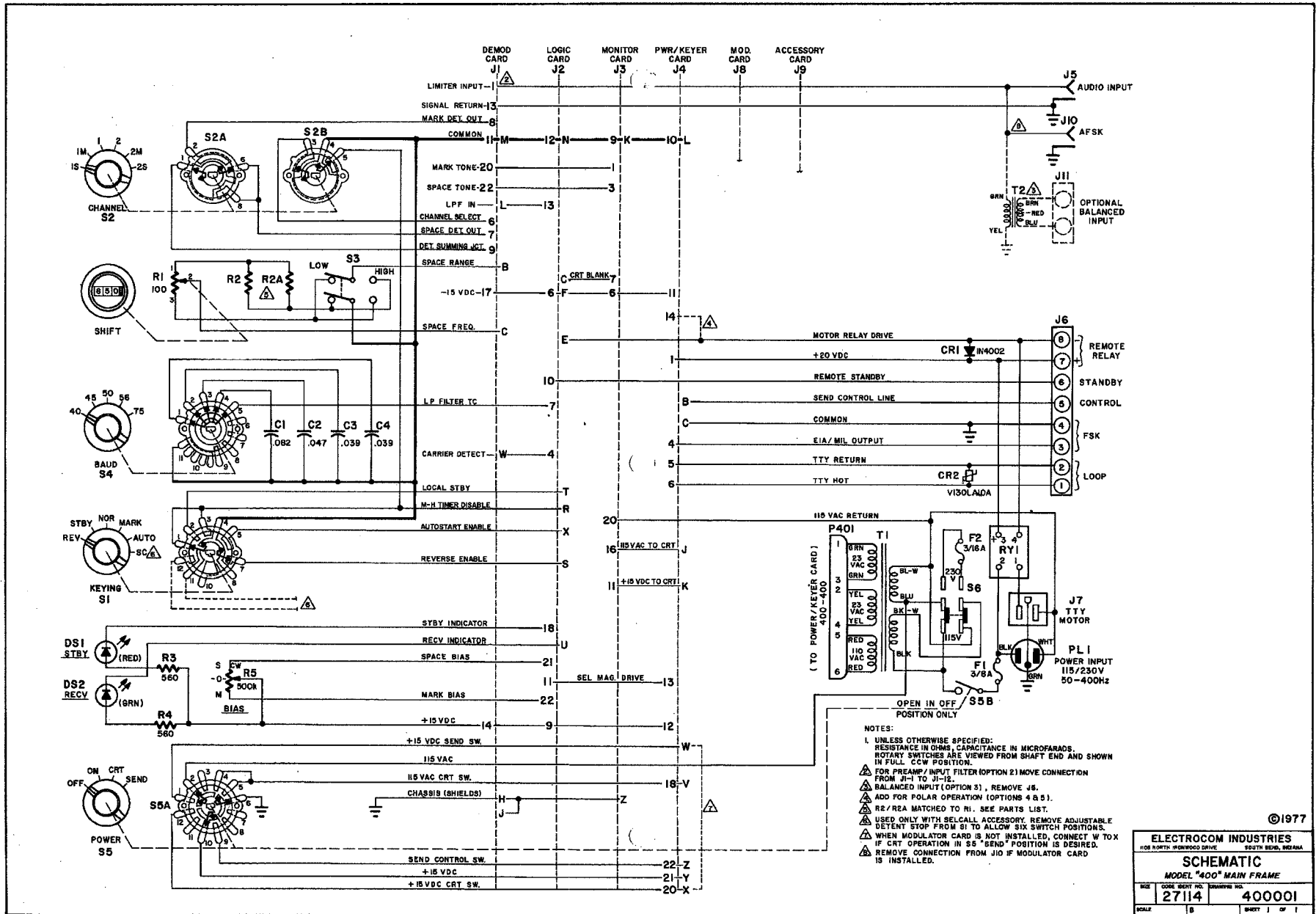
**CIRCUIT MODIFICATION TO SERIES 400 F. S. CONVERTERS
WHEN USING INPUT FILTER ASSEMBLY (OPTION #2)**

- (1) Move connection from J1-1 to J1-12. (See note 2 on schematic 400001.)
- (2) Add "Filter Preamp Option" components to Demodulator Card, p.n. 400-100 as shown on schematic 400101.
- (3) Connect "Input Filter Assembly" as shown on schematic 400003.
- (4) Mount switch S9, part number 41029, on the rear of "Channel" selector switch S2. The inner concentric knob (grey) controls the filter switch S9, while the outer knob (black) controls the channel switch S2.

When input filters are installed in the "1, 2, or 3" mounting positions of this assembly, switch S9 is used to select the proper filter for the tones being received. If the correct filter is not available, place this switch in the "Filter Out" position in order to bypass all input filters. The preamp will remain operative to increase the input sensitivity and provide attenuation below 1000 Hz.



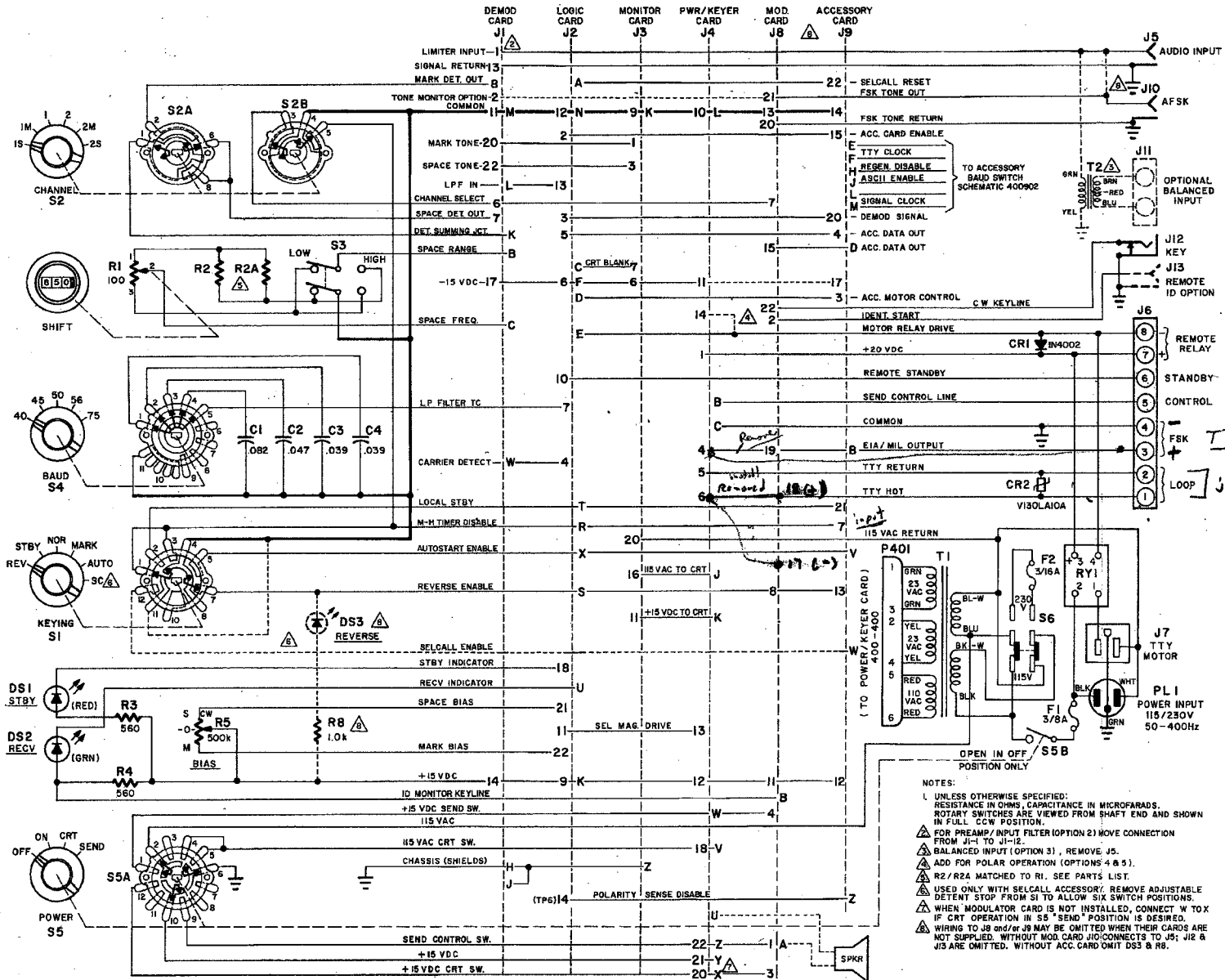
MAIN FRAME, Model 400, Schematic 400001



MAIN FRAME, Model 400, Schematic 400001

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ELECTROCOM INDUSTRIES			
1102 NORTH WOODBURN DRIVE		SOUTH BEND, INDIANA	
SCHEMATIC			
MODEL "400" MAIN FRAME			
REV.	CODE	ISSUE NO.	ISSUE NO.
	27114		400001
SCALE	1:1	SHEET	1 OF 1



TTL output 0-5V.0c
To Computer Input

Loop jumper ?

- NOTES:
- UNLESS OTHERWISE SPECIFIED: RESISTANCE IN OHMS; CAPACITANCE IN MICROFARADS. ROTARY SWITCHES ARE VIEWED FROM SHAFT END AND SHOWN IN FULL CCW POSITION.
 - FOR PREAMP/INPUT FILTER (OPTION 2) MOVE CONNECTION FROM J1-1 TO J1-2.
 - BALANCED INPUT (OPTION 3), REMOVE J5.
 - ADD FOR POLAR OPERATION (OPTIONS 4 & 5).
 - R2/R2A MATCHED TO R1. SEE PARTS LIST.
 - USED ONLY WITH SELCALL ACCESSORY; REMOVE ADJUSTABLE DETENT STOP FROM S1 TO ALLOW SIX SWITCH POSITIONS.
 - WHEN MODULATOR CARD IS NOT INSTALLED, CONNECT W TO X IF CRT OPERATION IN S5 "SEND" POSITION IS DESIRED.
 - WIRING TO J8 and/or J9 MAY BE OMITTED WHEN THEIR CARDS ARE NOT SUPPLIED. WITHOUT MOD CARD J10 CONNECTS TO J5; J12 & J13 ARE OMITTED. WITHOUT ACC. CARD OMIT DS3 & R8.

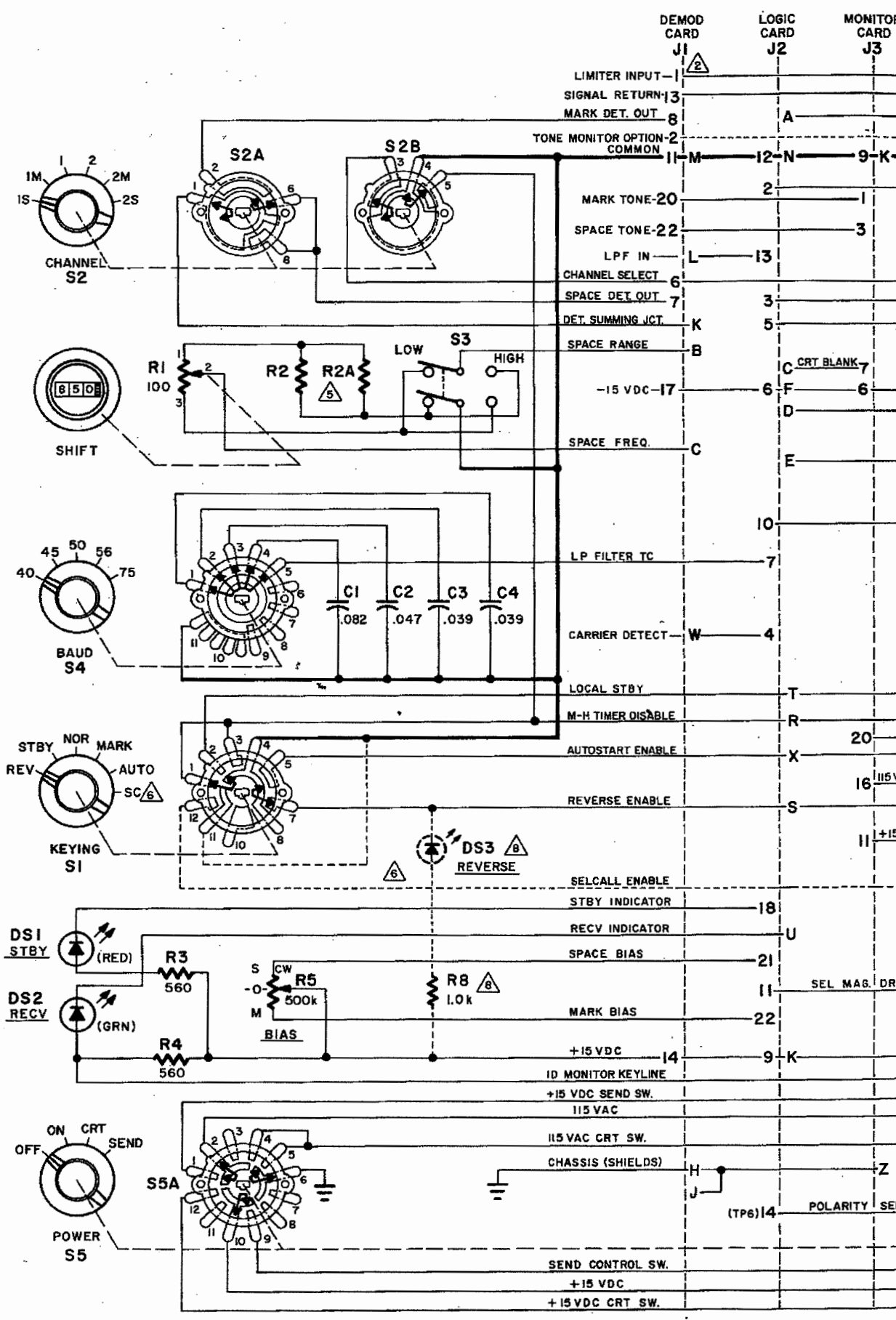
ELECTROCOM INDUSTRIES
1405 NORTH WOODWARD DRIVE, SOUTH BEND, INDIANA

SCHEMATIC

MODEL "400" MAIN FRAME

SIDE CODE SHEET NO. DRAWING NO. 27114 400001

SCALE C SHEET 1 OF 1



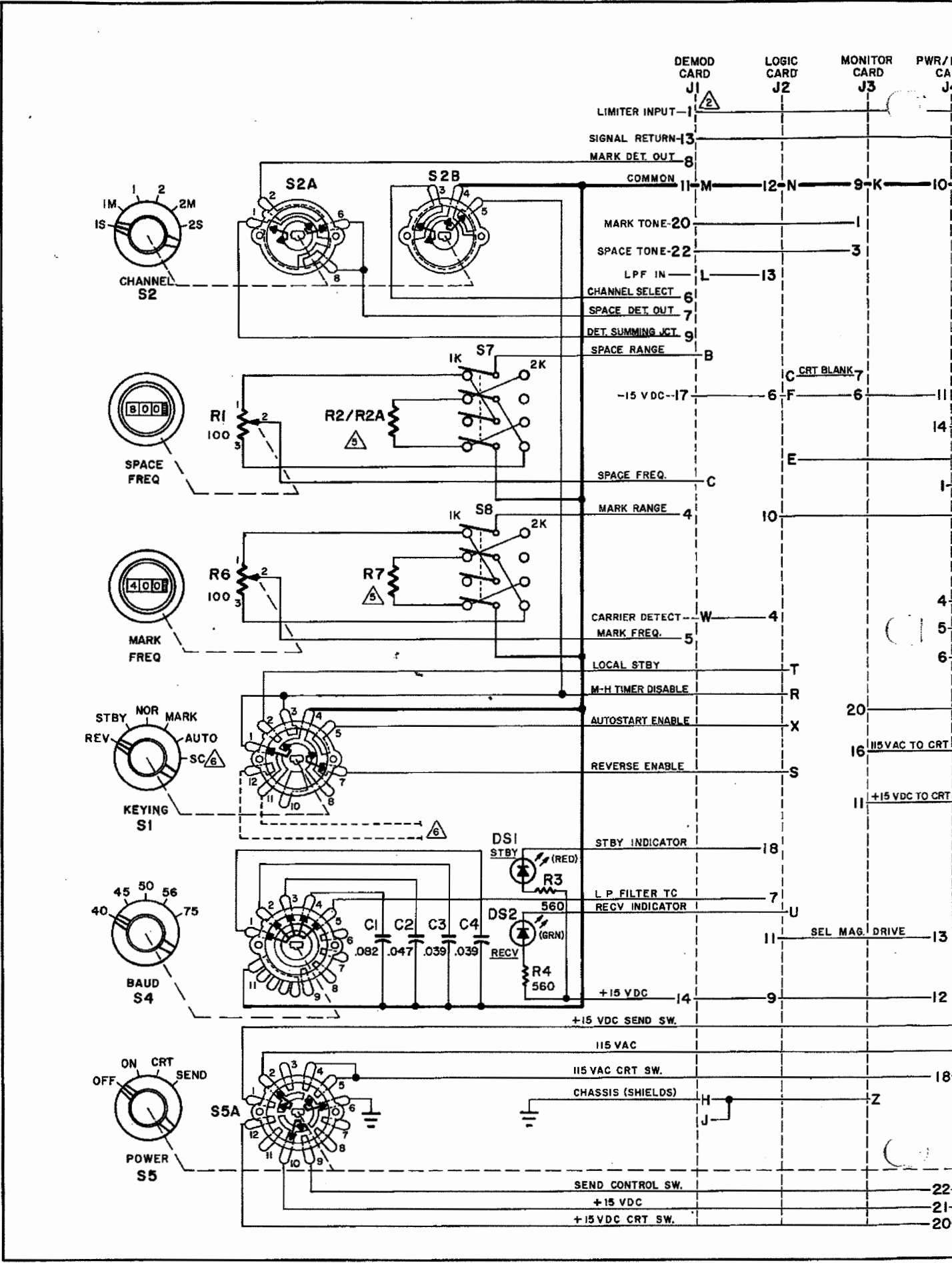
DEMOM CARD J1
LOGIC CARD J2
MONITOR CARD J3

- LIMITER INPUT-1
- SIGNAL RETURN-13
- MARK DET. OUT 8
- TONE MONITOR OPTION-2
- COMMON
- MARK TONE-20
- SPACE TONE-22
- LPF IN L-13
- CHANNEL SELECT 6
- SPACE DET. OUT 7
- DET. SUMMING JCT. K
- SPACE RANGE B
- 15 VDC-17
- SPACE FREQ. C
- LP FILTER TC 10
- CARRIER DETECT W-4
- LOCAL STBY T
- M-H TIMER DISABLE R
- AUTOSTART ENABLE X 20
- REVERSE ENABLE S 16
- SELCALL ENABLE
- STBY INDICATOR 18
- REC'D INDICATOR U
- SPACE BIAS 21
- MARK BIAS 22
- +15 VDC 14
- ID MONITOR KEYLINE 9 K
- +15 VDC SEND SW.
- 115 VAC
- 115 VAC CRT SW.
- CHASSIS (SHIELDS) H
- POLARITY SEND (TP6) 14 Z
- SEND CONTROL SW.
- +15 VDC
- +15 VDC CRT SW.

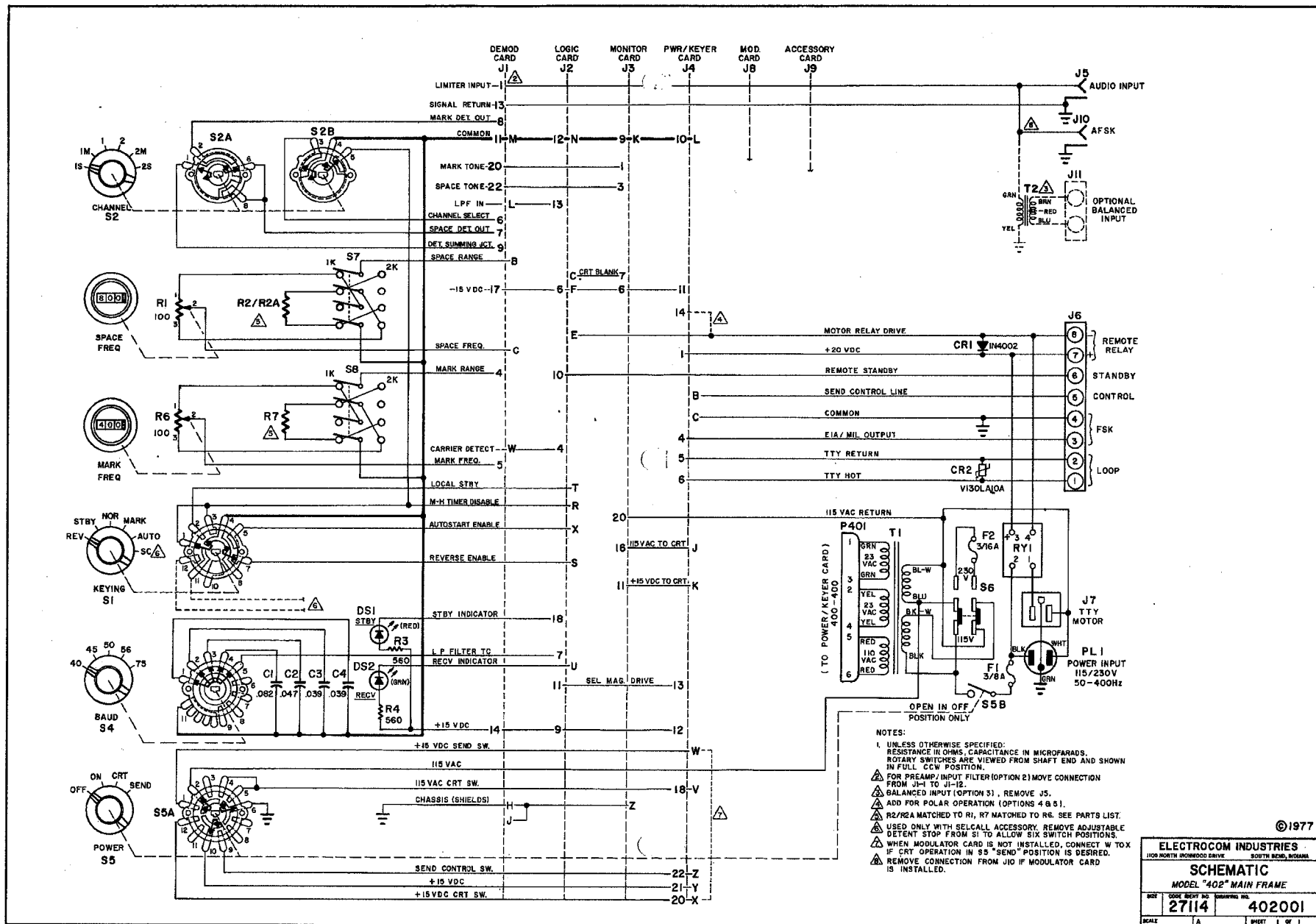
SCHEMATIC 402001

MAIN FRAME

Model 402

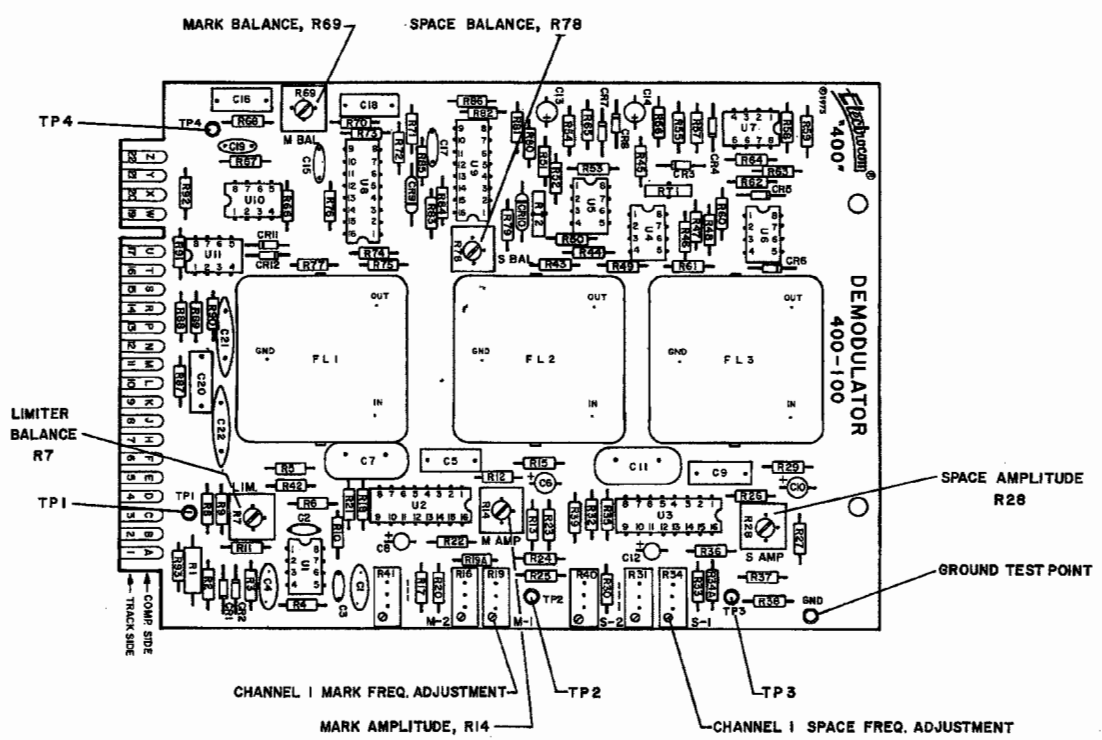


DEMOM CARD	LOGIC CARD	MONITOR CARD	PWR/CA
J1	J2	J3	J4
LIMITER INPUT-1			
SIGNAL RETURN-13			
MARK DET. OUT 8			
COMMON 11	M	12-N	9-K
MARK TONE-20			1
SPACE TONE-22			3
LPF IN L	13		
CHANNEL SELECT 6			
SPACE DET. OUT 7			
DET. SUMMING JCT 9			
SPACE RANGE B			
-15 VDC-17		C CRT BLANK 7	
SPACE FREQ. C	6	F	6
MARK RANGE 4		E	
CARRIER DETECT W			4
MARK FREQ. 5			5
LOCAL STBY T			6
M-H TIMER DISABLE R			
AUTOSTART ENABLE X			20
REVERSE ENABLE S			16
STBY INDICATOR 18			115 VAC TO CRT
L.P. FILTER TC 7			
REC.V INDICATOR U			
+15 VDC 14			
+15 VDC SEND SW. 9			
115 VAC 18			
115 VAC CRT SW. 18			
CHASSIS (SHIELDS) H			Z
SEND CONTROL SW. 22			
+15 VDC 21			
+15 VDC CRT SW. 20			



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ELECTROCOM INDUSTRIES
 1108 NORTH INWOOD DRIVE SOUTH BEND, INDIANA
SCHEMATIC
 MODEL "402" MAIN FRAME
 SIZE CODE BENT NO. DRAWING NO.
 27114 402001
 SCALE A SHEET 1 OF 1

FIGURE 10. COMPONENT LOCATION.
DEMODULATOR CARD P. N. 400-100



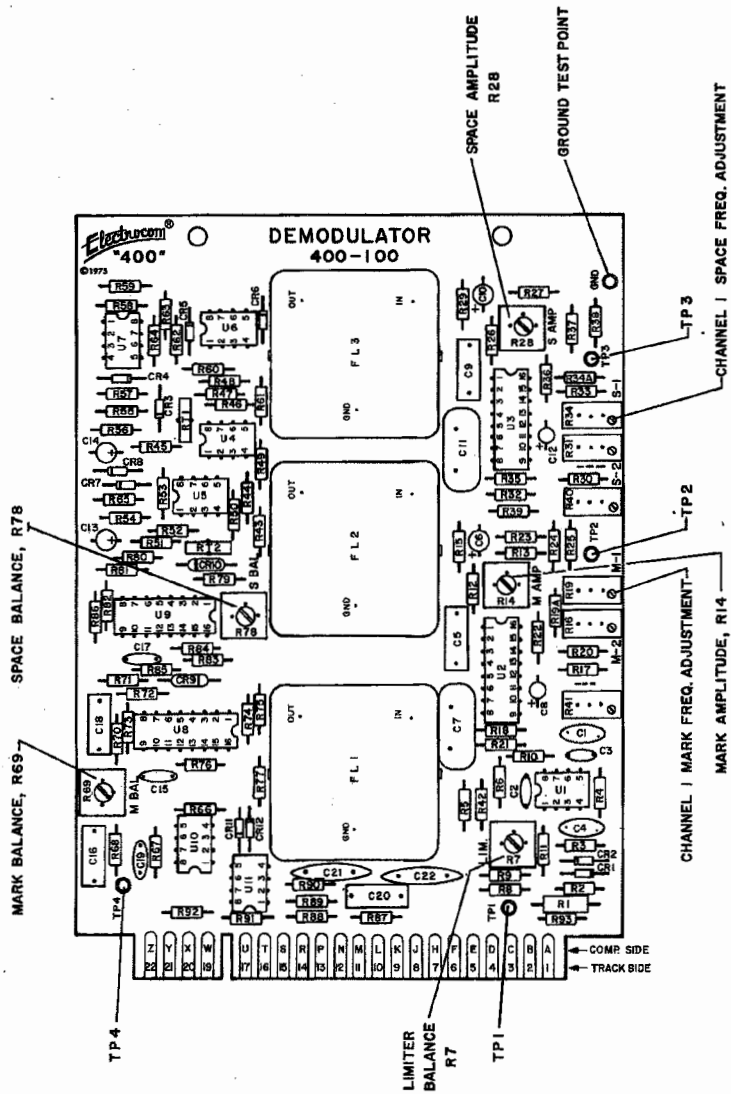
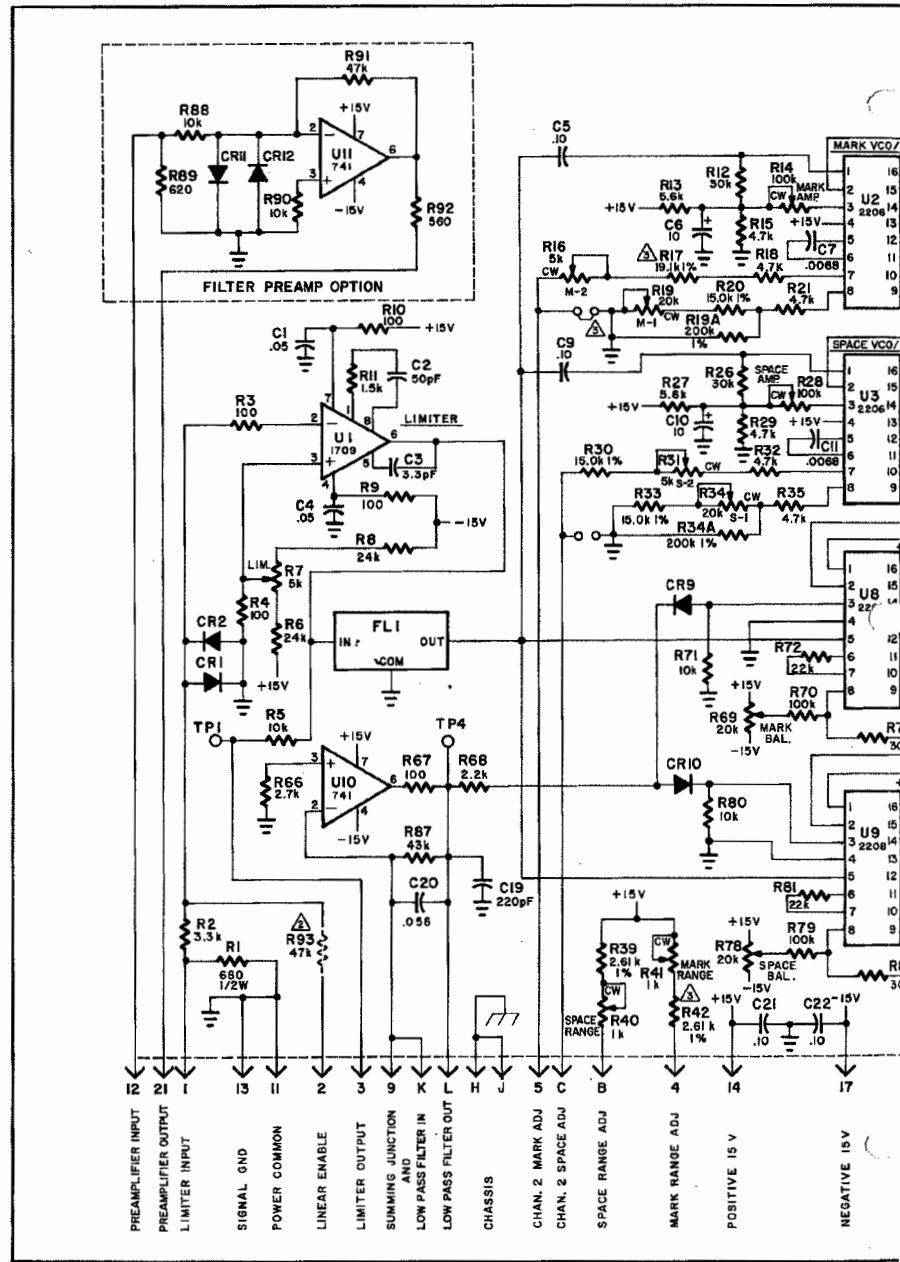


FIGURE 10. COMPONENT LOCATION, DEMODULATOR CARD P. N. 400-100



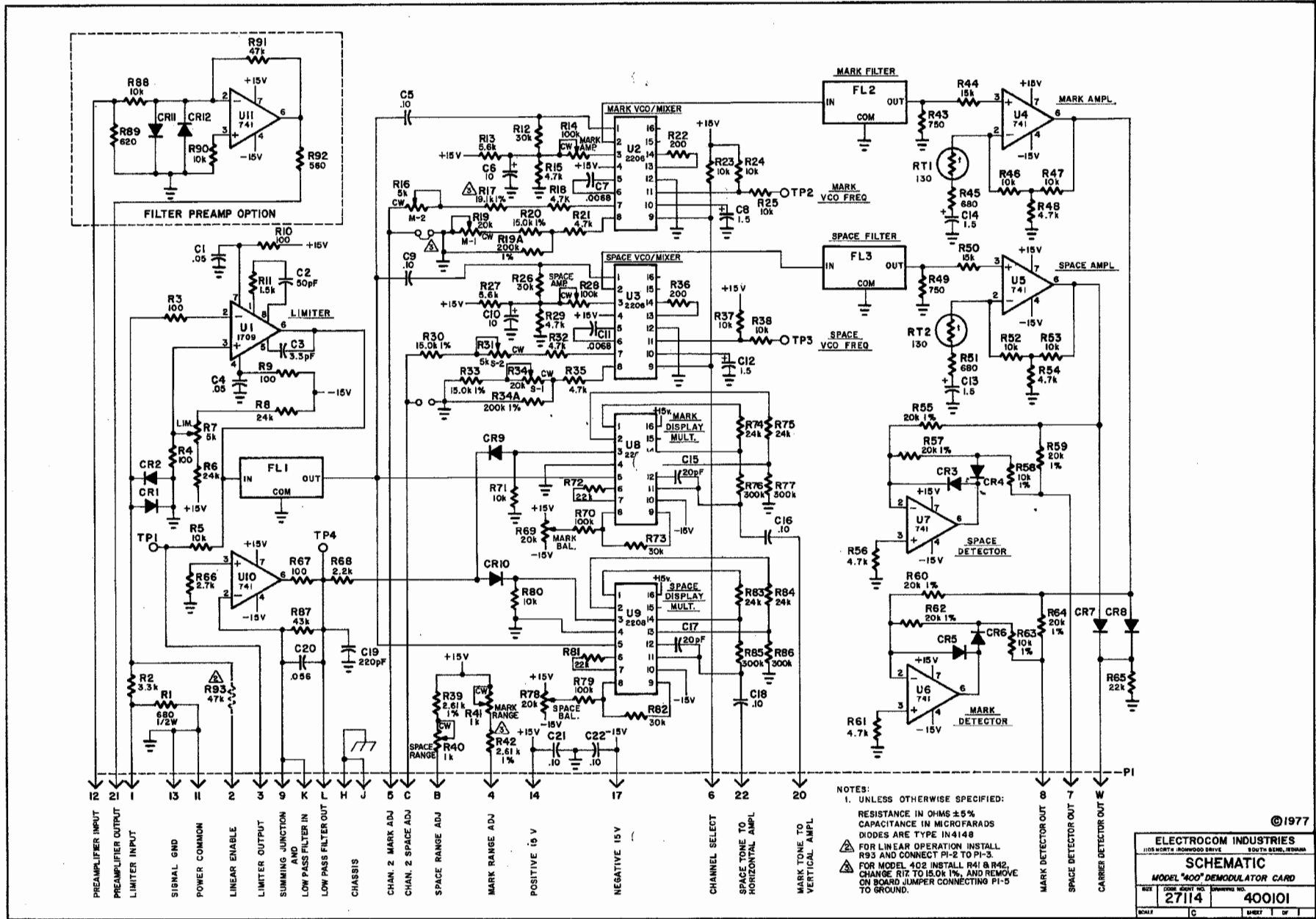
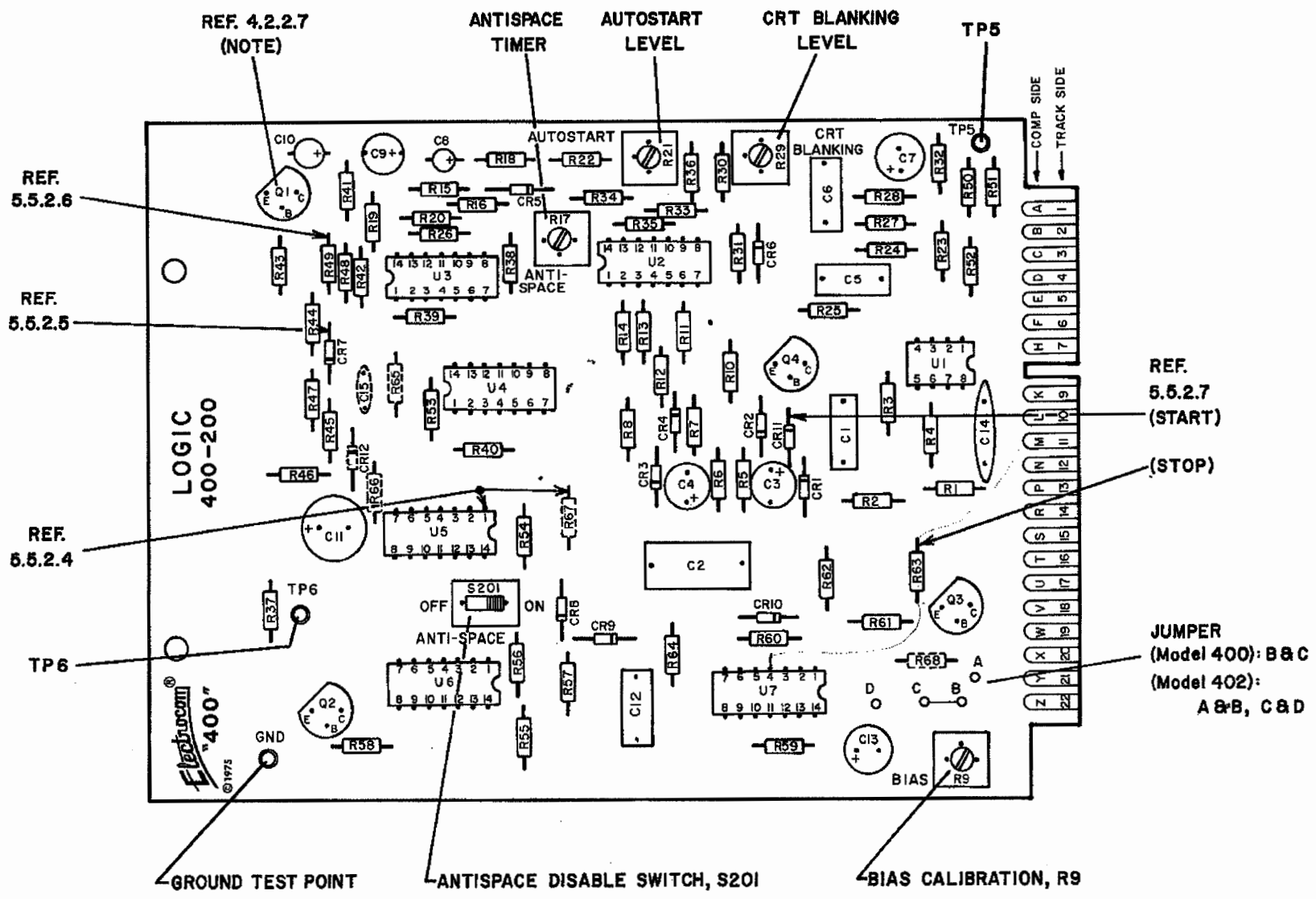


FIGURE 11, COMPONENT LOCATION,
LOGIC CARD P. N. 400-200



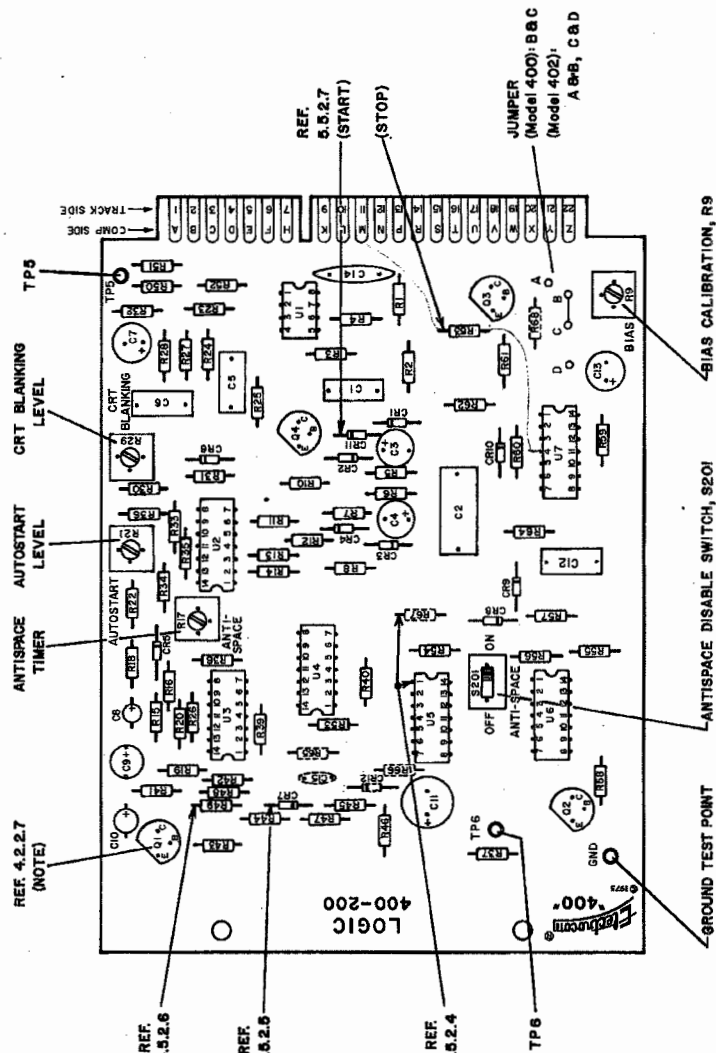
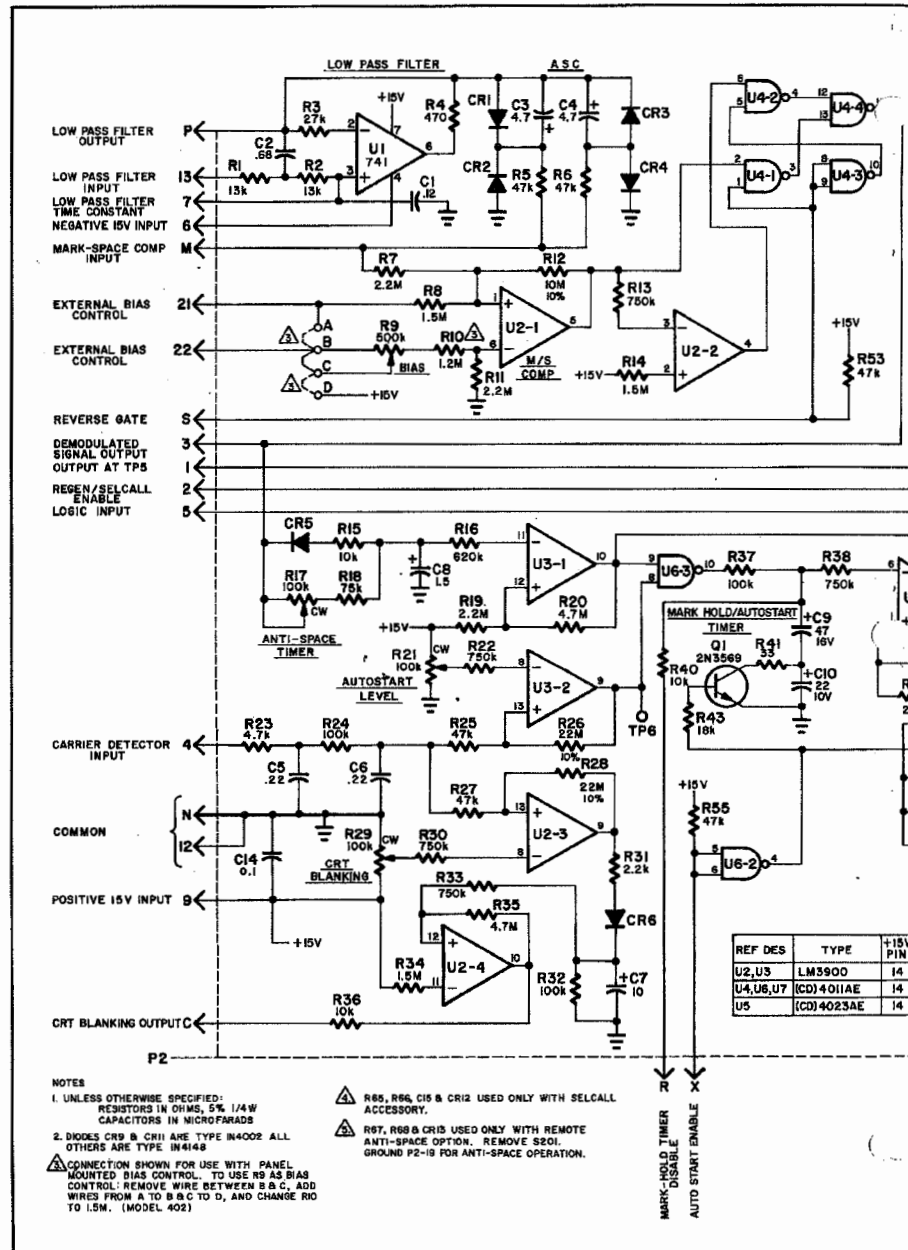
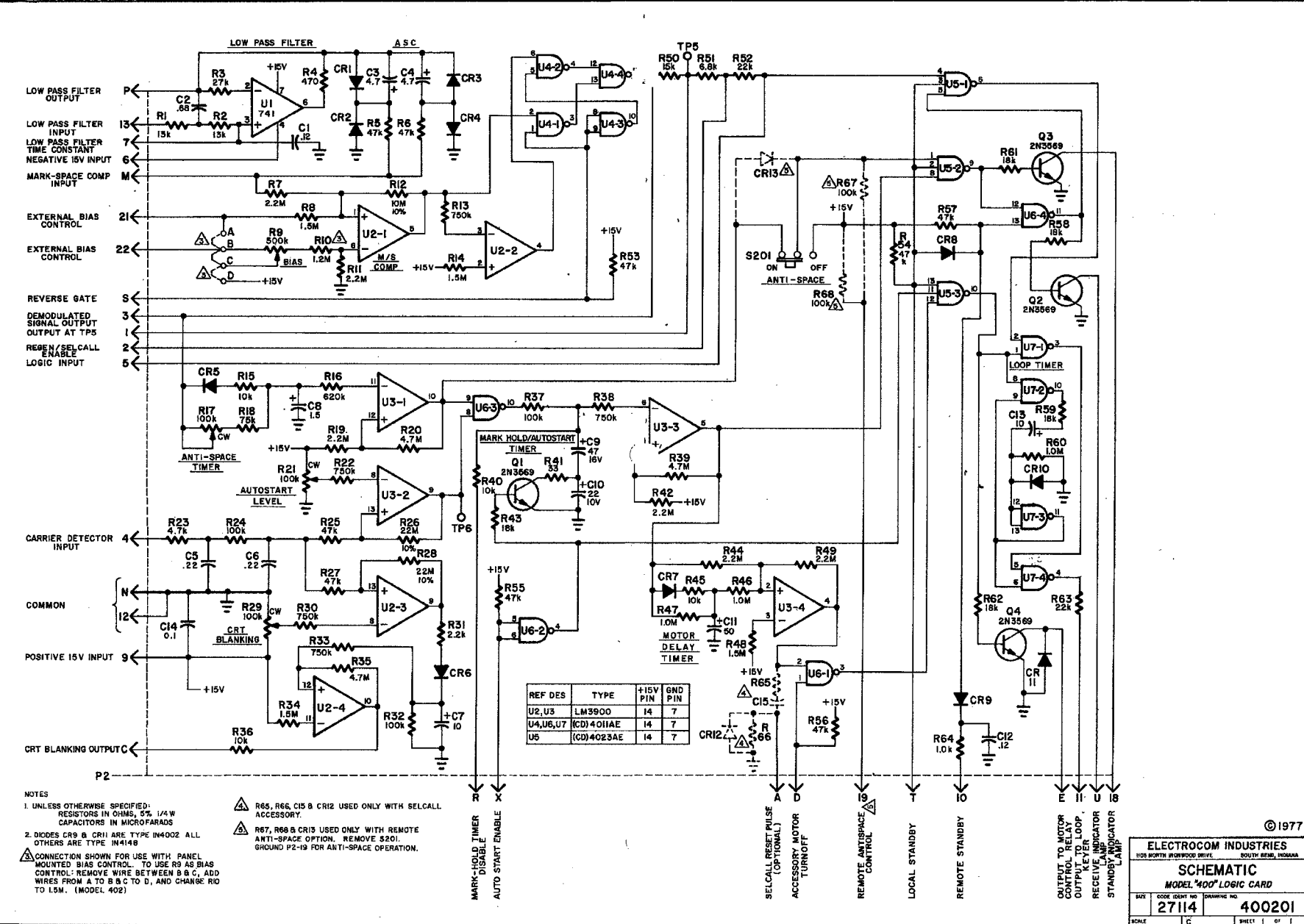


FIGURE 11. COMPONENT LOCATION,
LOGIC CARD P. N. 400-200





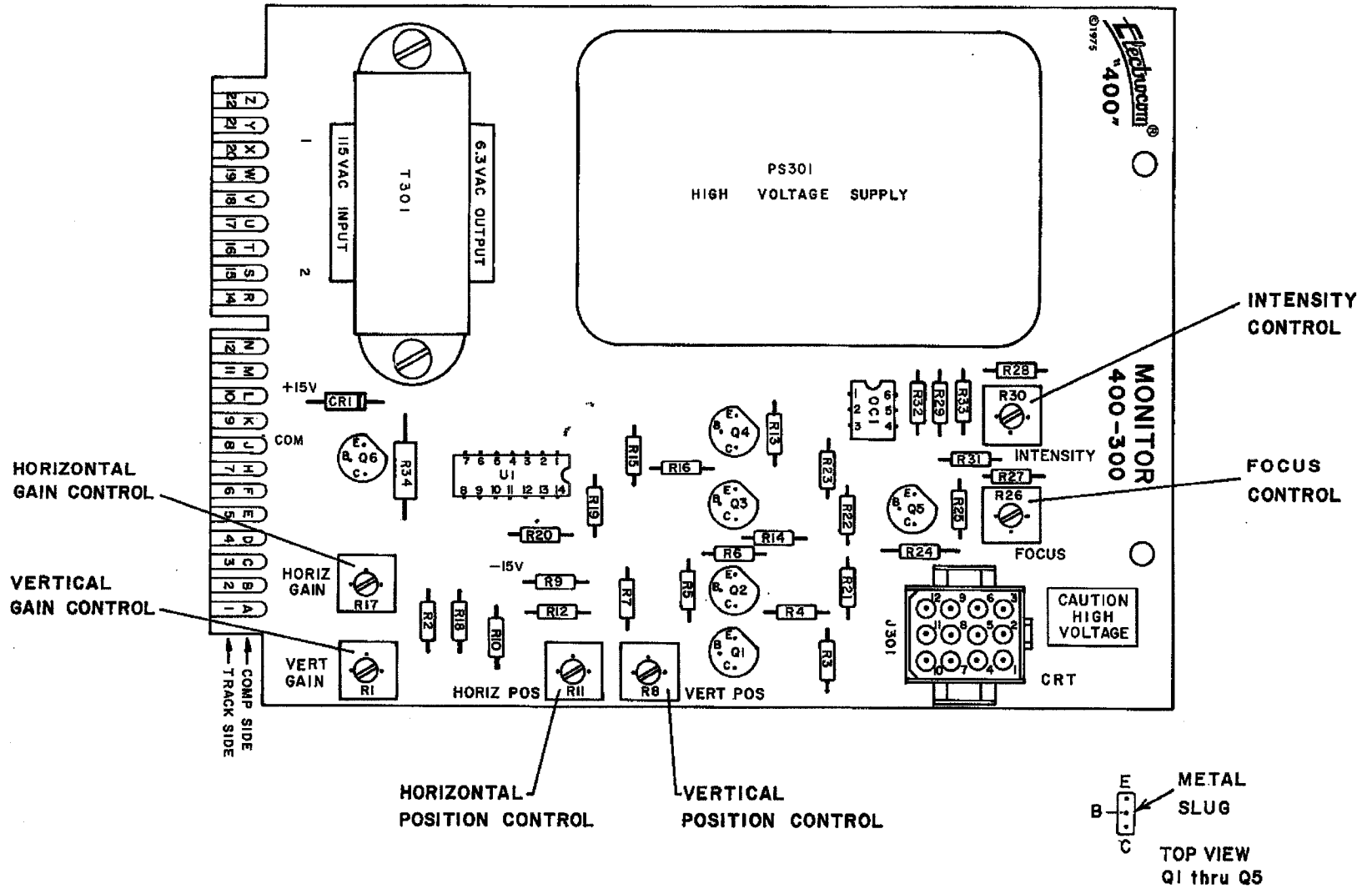
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ELECTROCOM INDUSTRIES
100 NORTH WOODSIDE DRIVE SOUTH BEND, INDIANA

SCHEMATIC
MODEL 400 LOGIC CARD

SIZE	CODE IDENT NO	DRAWING NO
	27114	400201
SCALE	C	SHEET 1 OF 1

FIGURE 12, COMPONENT LOCATION,
MONITOR CARD P. N. 400-300



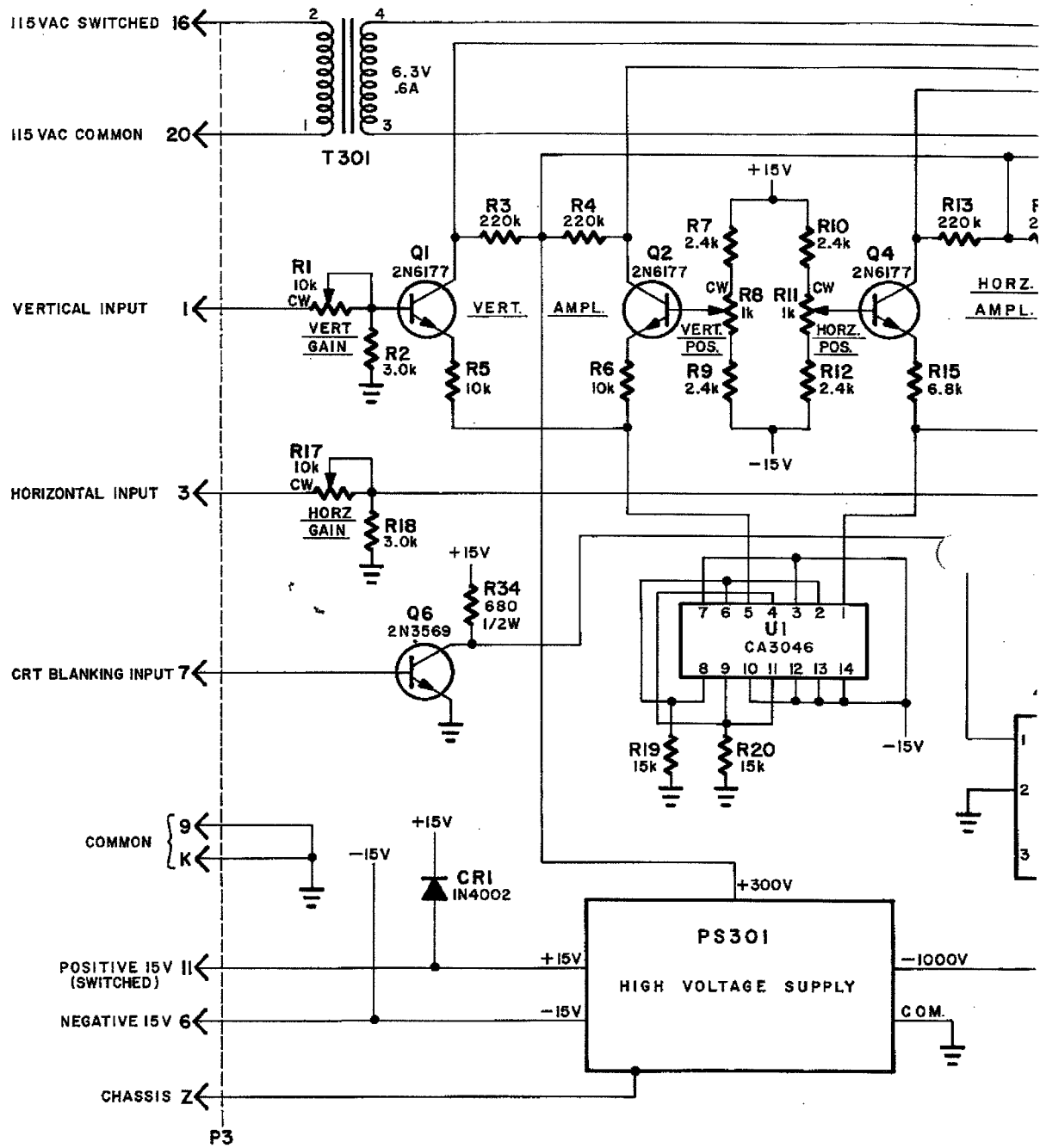
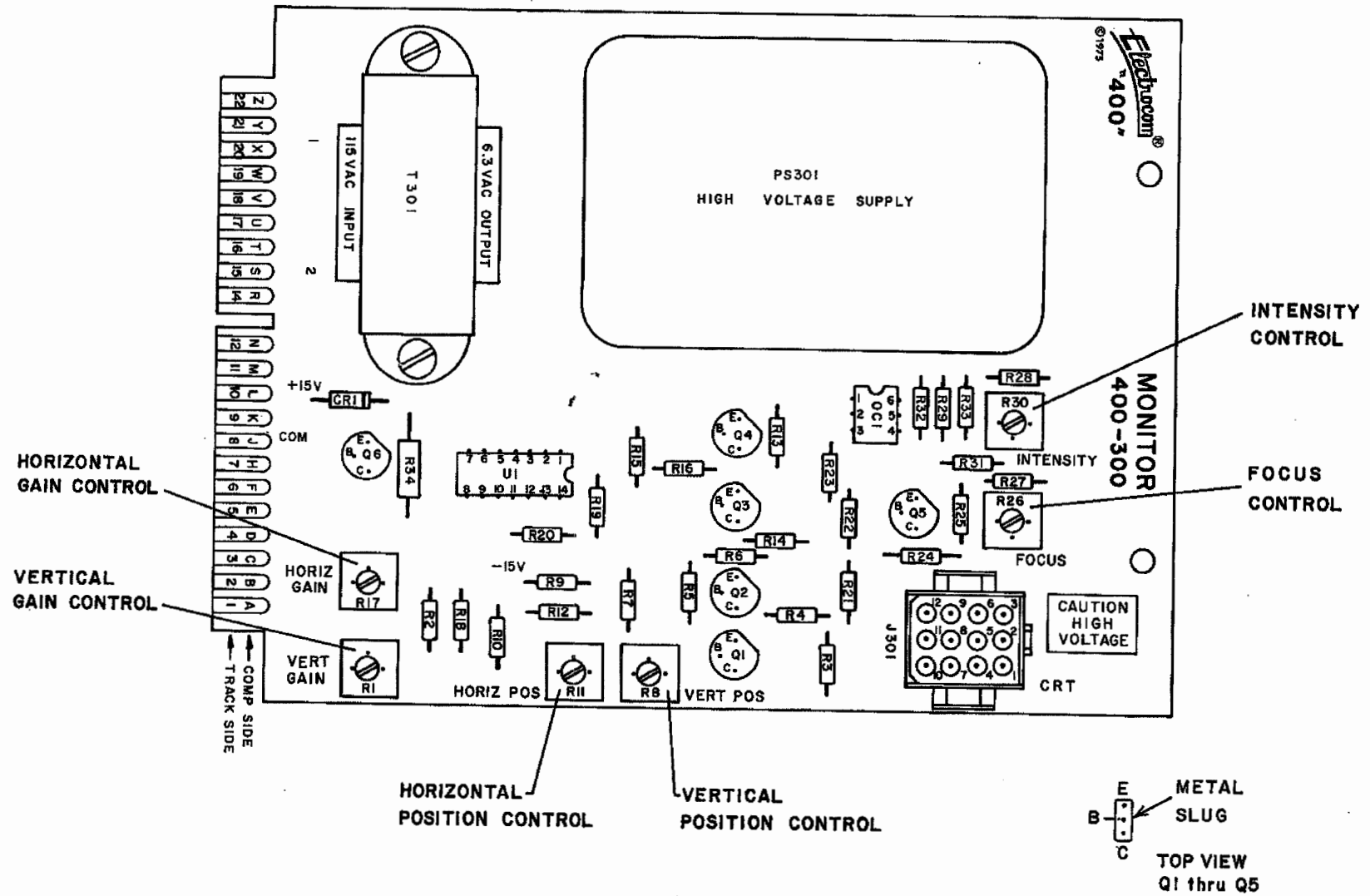


FIGURE 12. COMPONENT LOCATION,
MONITOR CARD P. N. 400-300



INSTALLATION OF POLAR CURRENT OPTIONS TO ELECTROCOM SERIES "400" FREQUENCY SHIFT CONVERTERS

CAUTION: When operating with either of these polar options, **DO NOT** allow the teleprinter loop circuit to become grounded at any point, or the circuit will not operate.

OPTION #4

This option provides DC polar loop current adjustable from ± 8 to ± 30 ma. into any loop resistance from 0 to 1000 ohms, and ± 8 to ± 20 ma. into any loop resistance from 0 to 2700 ohms. The loop current will remain constant regardless of power line variations.

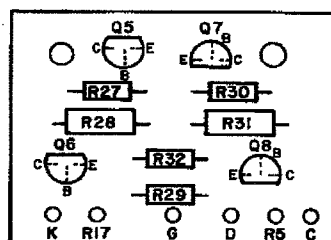
To install this option: (1) add components and change connections on PCB 400-400 as outlined in Note 3 on the Power/Keyer card schematic, 400-401, (2) change resistor R63 on the Logic Card, p. n. 400-200, from 22K to 13K ohms, 5%, $\frac{1}{4}$ watt, and (3) add a connection from J6-8 to J4-14. The unused yellow wire in the harness adjacent to terminal strip J6 is factory wired to J4-14. This connection is easily installed by splicing and insulating a short piece of wire between this yellow wire and J6-8.

OPTION #5

This option provides DC polar loop current adjustable from ± 8 to ± 40 ma. into any resistance from 0 to 1000 ohms, and ± 8 to ± 20 ma. into any resistance from 0 to 4000 ohms. Current will remain constant regardless of loop resistance or power line variations.

To install this option: (1) add components and change connections on PCB 400-400 as outlined in Note 3 on Power/Keyer card schematic 400401, omitting resistors R17, R24 & R25, (2) install a 22K ohm, 5%, $\frac{1}{4}$ watt resistor for R17, (3) install polar interface subassembly, p. n. 400405, to the points indicated on the Power/Keyer schematic 400401, and (4) add connection from J6-8 to J4-14 as described for Option #4 above. When operating at a maximum of ± 20 ma. into a 0 to 4000 ohm load, change R3 on the Power/Keyer card from 100 ohms to 1000 ohms, 5%, 1 watt. If higher currents are required do not change R3; however, use caution not to ground the teleprinter loop even momentarily as permanent damage to transistors Q5 or Q7 may result.

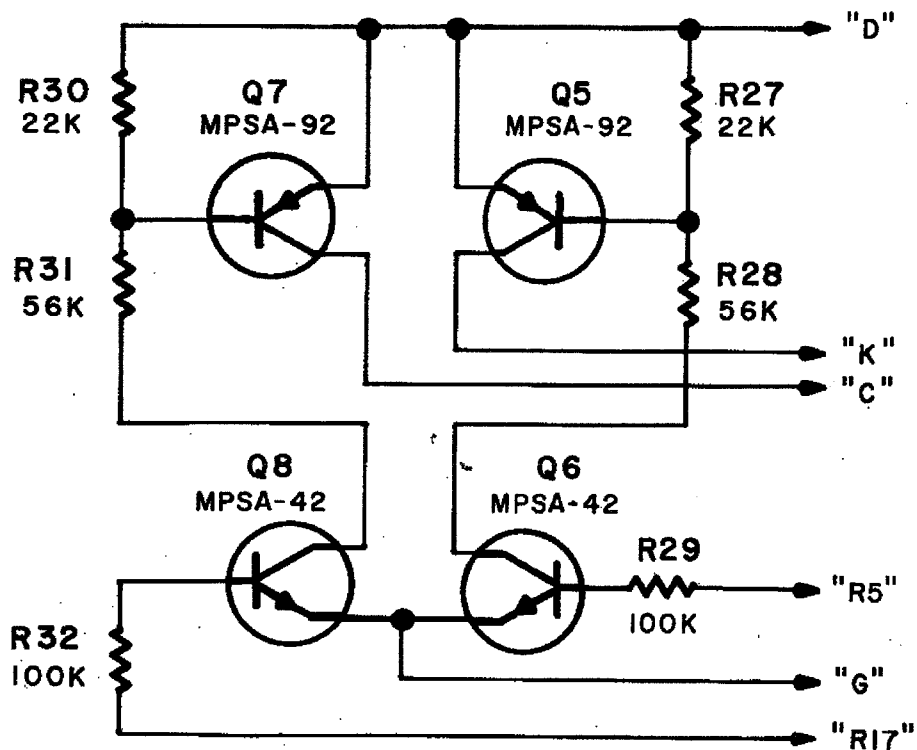
Component location on subassembly 400405:



SCHEMATIC

POLAR INTERFACE SUBASSEMBLY, P. N. 400405

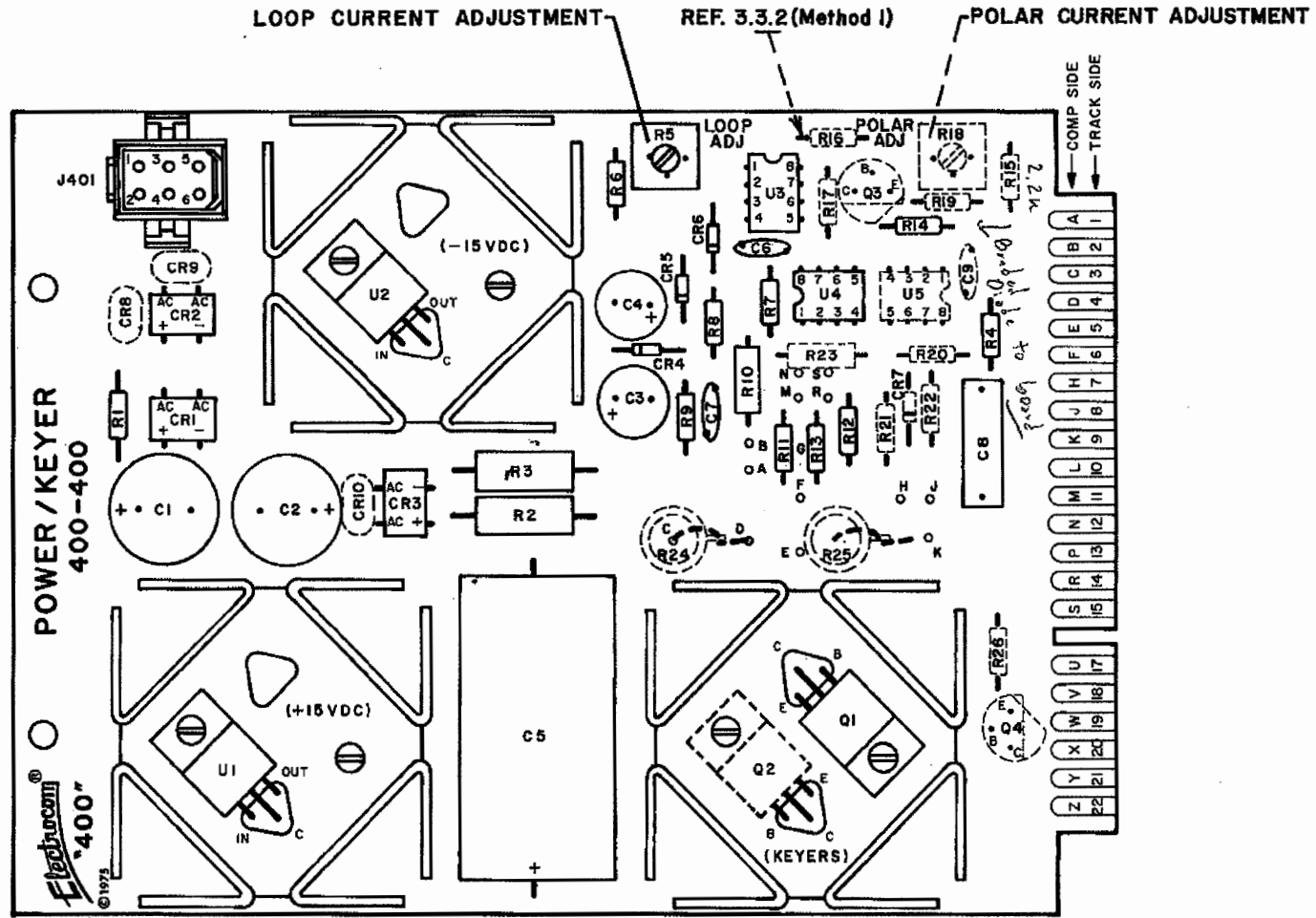
(FOR USE WITH OPTION #5)

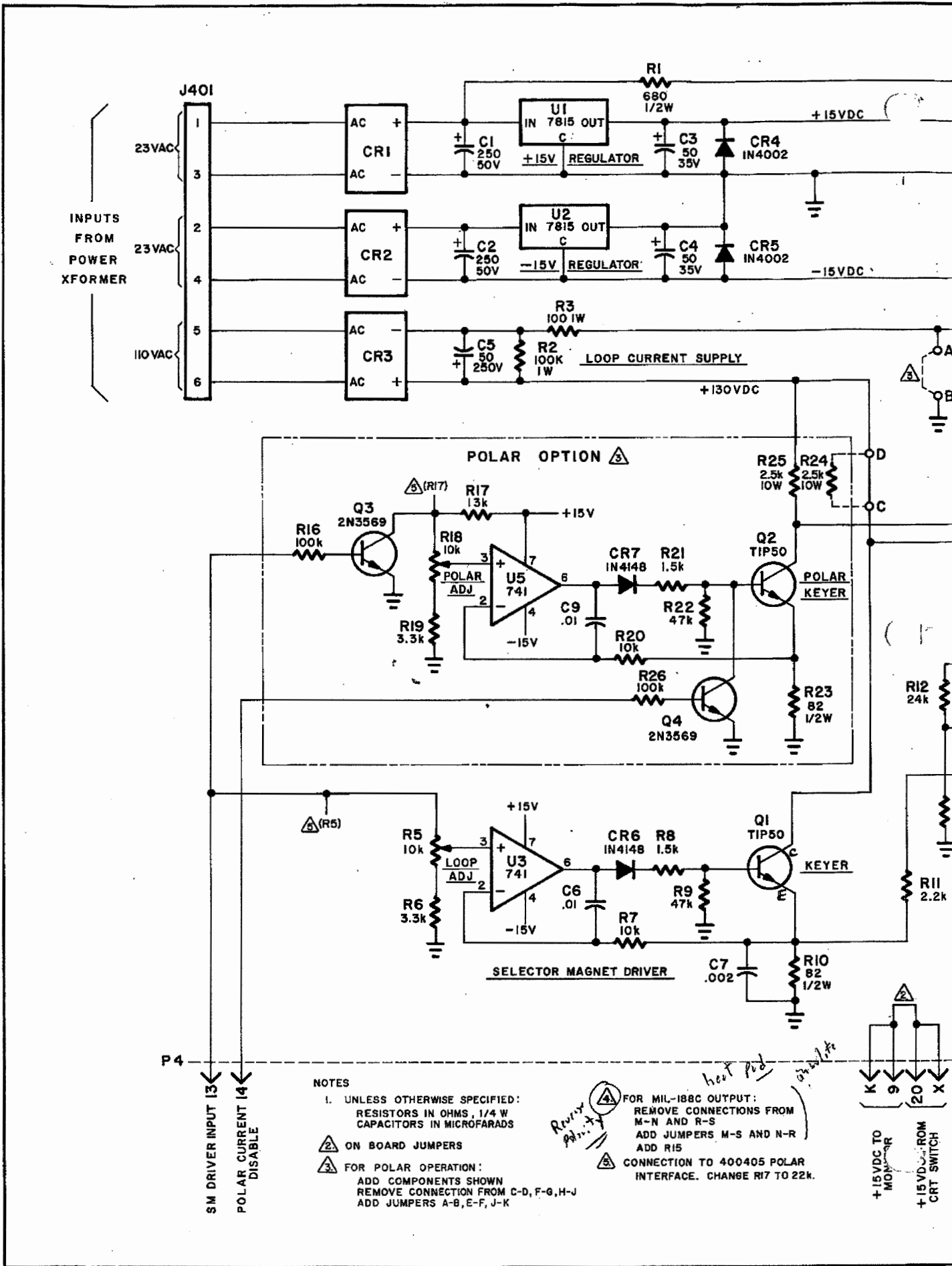


NOTE:

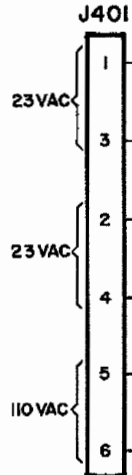
CONNECT POINTS "C, D, G, K, R5, & R17" TO SAME POINTS ON POWER/KEYER CARD 400-400, SCHEMATIC NO. 400401.

FIGURE 13, COMPONENT LOCATION,
POWER/KEYER CARD, P. N. 400-400

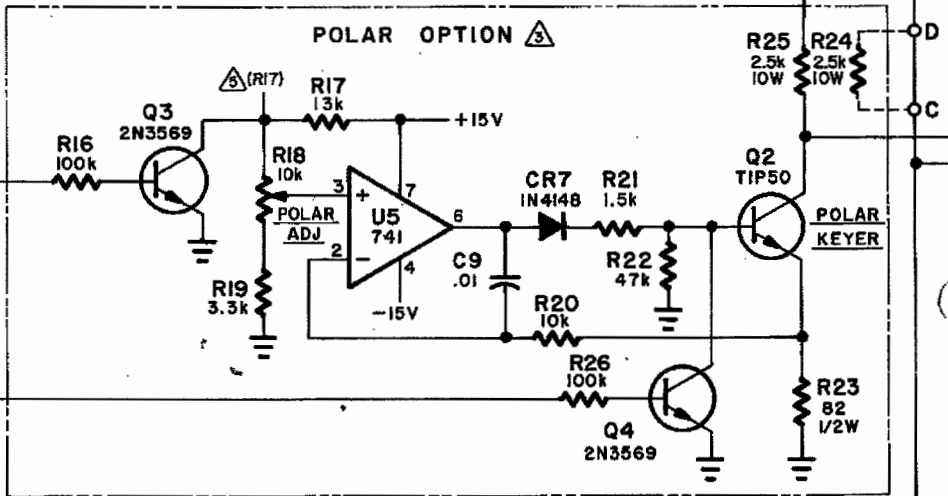




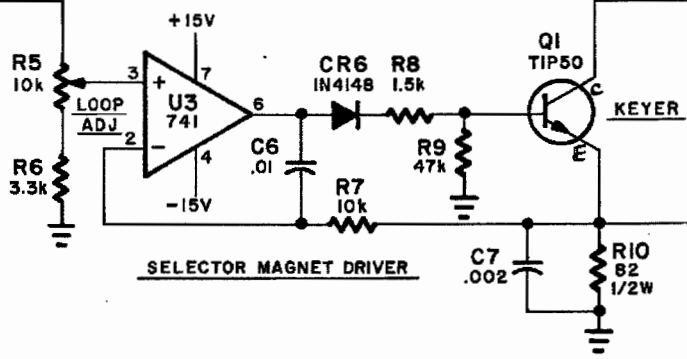
INPUTS FROM POWER XFORMER



POLAR OPTION



SELECTOR MAGNET DRIVER



P4

SM DRIVER INPUT 13

POLAR CURRENT 14

DISABLE

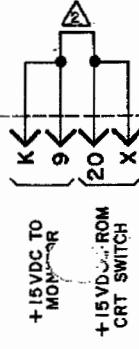
NOTES

- UNLESS OTHERWISE SPECIFIED:
RESISTORS IN OHMS, 1/4 W
CAPACITORS IN MICROFARADS
- ② ON BOARD JUMPERS
 - ③ FOR POLAR OPERATION:
ADD COMPONENTS SHOWN
REMOVE CONNECTION FROM C-D, F-G, H-J
ADD JUMPERS A-B, E-F, J-K
 - ④ FOR MIL-188C OUTPUT:
REMOVE CONNECTIONS FROM
M-N AND R-S
ADD JUMPERS M-S AND N-R
ADD R15
CONNECTION TO 400405 POLAR
INTERFACE. CHANGE R17 TO 22k.

Revise

heat pad

capacitor



INSTRUCTIONS

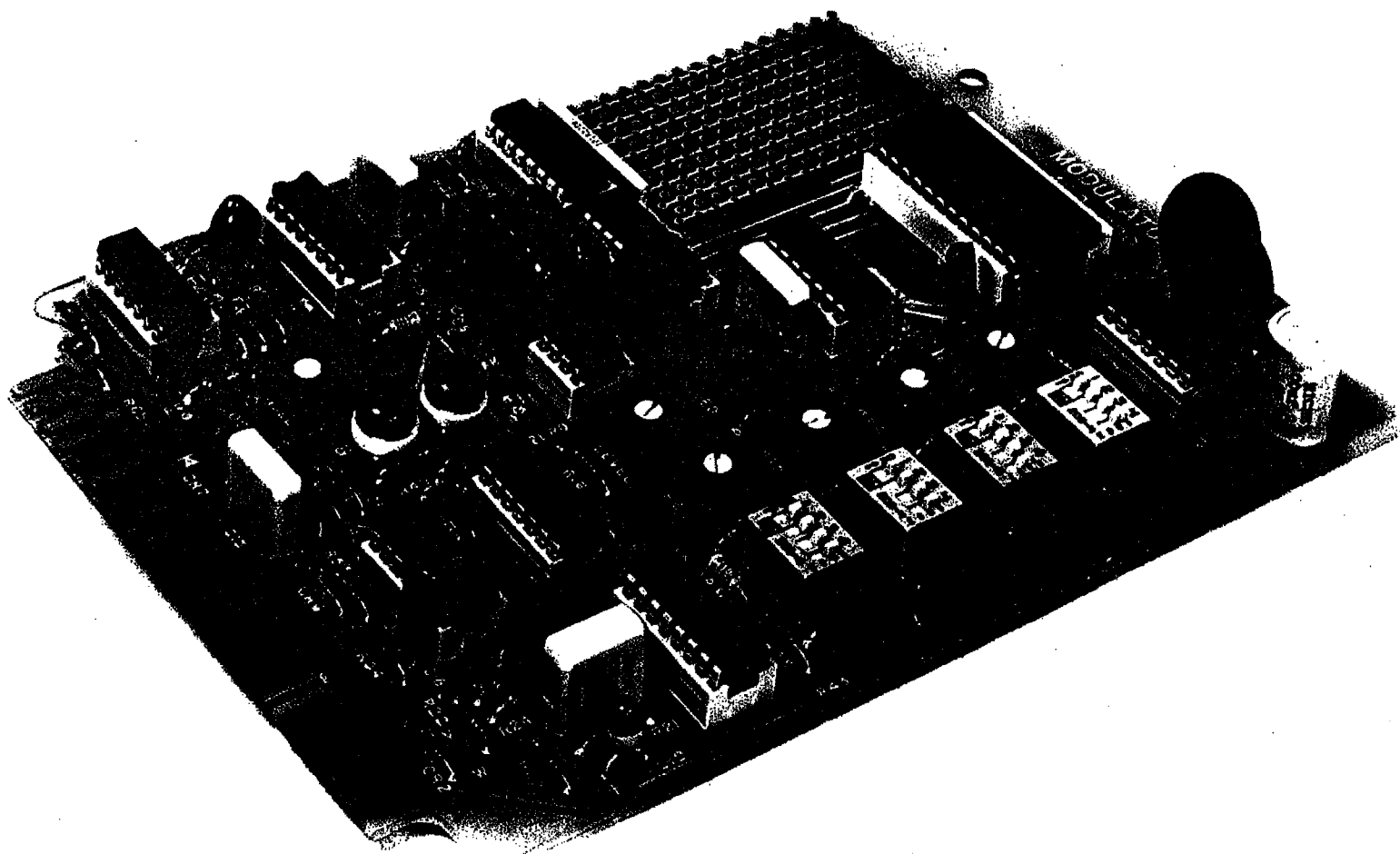
400-800

MODULATOR CARD

Electrocom[®] INDUSTRIES

Communications Products and Systems

1105 NORTH IRONWOOD DRIVE, SOUTH BEND, INDIANA 46615



Electrocom[®] INDUSTRIES

Communications Products and Systems

1105 NORTH IRONWOOD DRIVE, SOUTH BEND, INDIANA 46615

SECTION 1, DESCRIPTION, ELECTROCOM[®] MODULATOR, P.N. 400-800

- 1.1 The Electrocom[®] Modulator Card, p.n. 400-800, is an audio frequency shift tone keyer designed to plug into a dual 22 pin edge card connector within the "Series 400" F. S. Converters. Make-break keying is also incorporated to allow CW transmission. The addition of this assembly to the converter provides a complete modem suitable for transmitting or receiving AFSK or FSK (when used with SSB transmitters) signals. When installed in the 400 converters, operation is controlled by the existing front panel switches. The "keying" selector selects normal or reverse keying polarity while the "channel" switch selects either of two tone pairs. The tone output is turned on when the "power" switch is in the "send" position. All circuitry with the exception of the power supply is contained on one printed circuit card. Although operating voltage is normally supplied from the positive 15 volt supply in the converter, this modulator card may be operated independently from another 15 volt regulated power source.

The 400-800 modulator features continuously variable tone frequencies, each of which is easily programmed over a frequency range from 1000 to 3200 Hz. Excellent resolution and frequency stability are maintained over the full range through the use of binary coded switches and 20 turn trimmers. Amplitude stability over the full temperature range is optimized with compensation circuitry. Two modes of operation are available to best suit the requirements of the total communications system. (1) When a transmitter has uniform audio frequency response, all tones are operated at the same output level. For this mode, switching at the peak of the sine wave produces the smoothest transition from one tone to the other. (2) Since some transmitters have varying response throughout their audio passband, provision has been incorporated to vary the output level of each tone independently. When operating in this mode zero crossing switching is used to provide the smoothest transition between tones. Thus, extremely clean, transient free keying is achieved in either mode.

For systems requiring Morse code identification, an optional automatic ID generator may be installed on the circuit board. The code is easily programmed with diodes. Identification may be either by make-break or narrow shift keying. When narrow shift ID is used, the information is keyed above and below the normal tone by about 50 Hz. in order to provide a total shift of 100 Hz. yet maintain both tones within the passband of the filter channel. (This circuit may also be adapted to provide RTTY code identification.) The automatic sequence may be initiated whenever the tone is turned on or off. When turned off the transmitter will operate until identification is completed, after which the system will return to receive. During ID periods the green "receive" indicator on the front of the 400 will blink the code as it is transmitted. The code may be monitored audibly by installing optional sidetone monitor components.

Various Modulator assembly levels and options provide the most suitable features for a particular system. The assembly may be increased to a higher level, and/or options added by installing additional components. The levels and options available are as follows:

Level #1: Provides one tone pair, constant output amplitude and peak wave switching.

Level #2: Provides two tone pairs with a common mark frequency.

Level #3: Provides two tone pairs with completely independent tones.

Option A: Provides adjustable tone amplitude for each tone, and zero crossing switching. This option may be used only with levels 2 and 3.

Option B: Adds automatic identification feature with "blinking lamp" monitor. Identification is initiated when the tone is turned on or off.

Option C: Initiates identification from a momentary ground connection on a rear panel jack.

Option D: Adds sidetone oscillator and speaker circuitry for audibly monitoring identification.

Unless otherwise specified, the Modulator Card will be supplied to Level #2. For other configurations, specify the level followed by all options desired.

1.2 - SPECIFICATIONS:

Audio output: 0 dbm. (1 mv. into 600 ohms), adjustable +1, -4 db.
(high impedance load, adjustable from .9 to 2.0 volts rms)

Compensation range (Option A): 2.5 db at 0 dbm., 4.5 db at -4 dbm.

Output impedance: 600 ohms nominal, unbalanced

Operating temperature range: 0 to 65° C.

Tone frequencies: Adjustable from 1000 to 3200 Hz.

Frequency stability: better than 5 Hz.

F. S. Input Signal: EIA RS232 voltage levels supplied from 400 converter
(Mark, -15 to .6 volts; Space, +12 to 15 volts)

Optional: Current input, 20 to 60 ma. mark, 0 ma.
space, optically isolated; or contact closure
with 4 ma. circulated thru contacts.

CW input signal: keying contacts

Maximum FS keying speed: 150 bauds

Power Input: 15±.6 volts, 25 ma. nominal (75 ma. avg with option D.)

Dimensions: 15.875 cm (6.25 inches) x 11.43 cm (4.5 in.) x 1.91 cm (.75 in.)
maximum height

Weight: 140 grams (4.94 oz.)

Interconnect: dual 22 pin edge card connector, .156" contact spacing,
.062" circuit board

SECTION 2, INSTALLATION

2.1 LOCATION

Modulator Card 400-800 plugs into connector J8, located directly below the Power/Keyer Card in the 400 series converters. J8 and its associated wiring will be factory installed when this card is supplied with the converter, or when specially ordered in anticipation of future system expansion. The edge of the card opposite that of the connector attaches with two screws into the card support rail.

2.2 EXTERNAL CONNECTIONS

The following connections to the Modulator Card are available on the rear panel of the series 400 converters:

2.2.1 AFSK Jack

This phono type jack supplies unbalanced 600 ohm AFSK output at a level of 0 dbm. when transmitting. This afsk information feeds directly to the audio input circuit of transmitters designed to accept 0 dbm. In systems where a 0 dbm. line input is not available, the modulator may be fed into a low level microphone input. However, the audio voltage will have to be reduced. A fixed attenuator is recommended to prevent the possibility of overdriving the preamplifier in the transmitter, which will result in distortion and non-linear operation. This attenuator should be placed at the transmitter input so that any noise which may be coupled into the interconnecting cable will also be attenuated and the maximum signal to noise ratio maintained. Recommended attenuator circuits are shown in Figure 1. Circuit A is a simple voltage divider which is satisfactory in most installations where line lengths are short. Circuit B provides a 600 ohm unbalanced constant impedance attenuator. These attenuators provide a voltage input to the transmitter of 15 to 20 mv. rms. This voltage may be varied with the level control, R17, on the Modulator Card.

2.2.2 Key

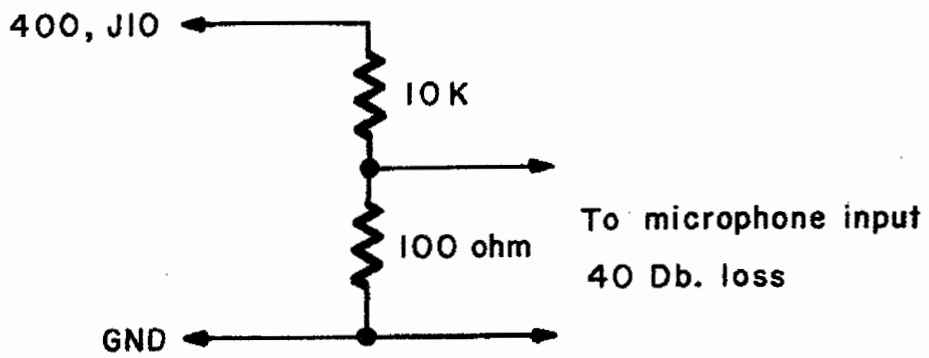
This miniature closed circuit jack is provided for CW keying of the modulator tone. It allows CW identification when required, and also provides a means of CW keying SSB transmitters not containing CW keying circuitry. The "key up" condition mutes the AFSK tone by reducing its output more than 40 db. Waveshaping is provided in order to produce clean, click-free keying.

When a key is connected to this jack, it MUST be closed during rtty transmission; otherwise, there will be no tone output.

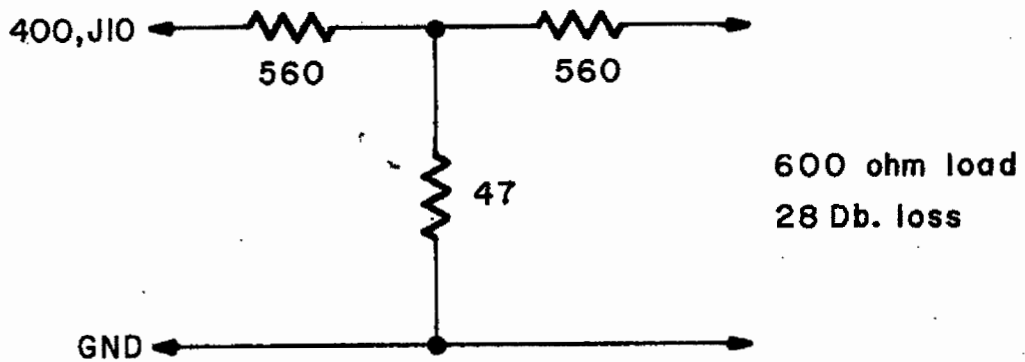
2.2.3 Send Control (CTRL)

Terminal J6-5 on the converter connects to the "Send" position of the power switch and to the "Send Control" line of the Modulator Card. Grounding this terminal either externally or by placing the power switch in the SEND position will provide full tone output from the modulator.

The circuitry used allows direct connection to most solid-state logic and dc control systems for controlling the transmit-receive operation of the entire rtty system. Figure 2a shows typical interconnections for use with a transmitter having positive voltage on the PTT line. The diode shown allows voltages below 14 volts to be connected to the converter without interaction. For voltages between 14 and 40 vdc the diode may be eliminated. If the PTT



CIRCUIT A



CIRCUIT B

ATTENUATOR CIRCUITS

FIGURE 1

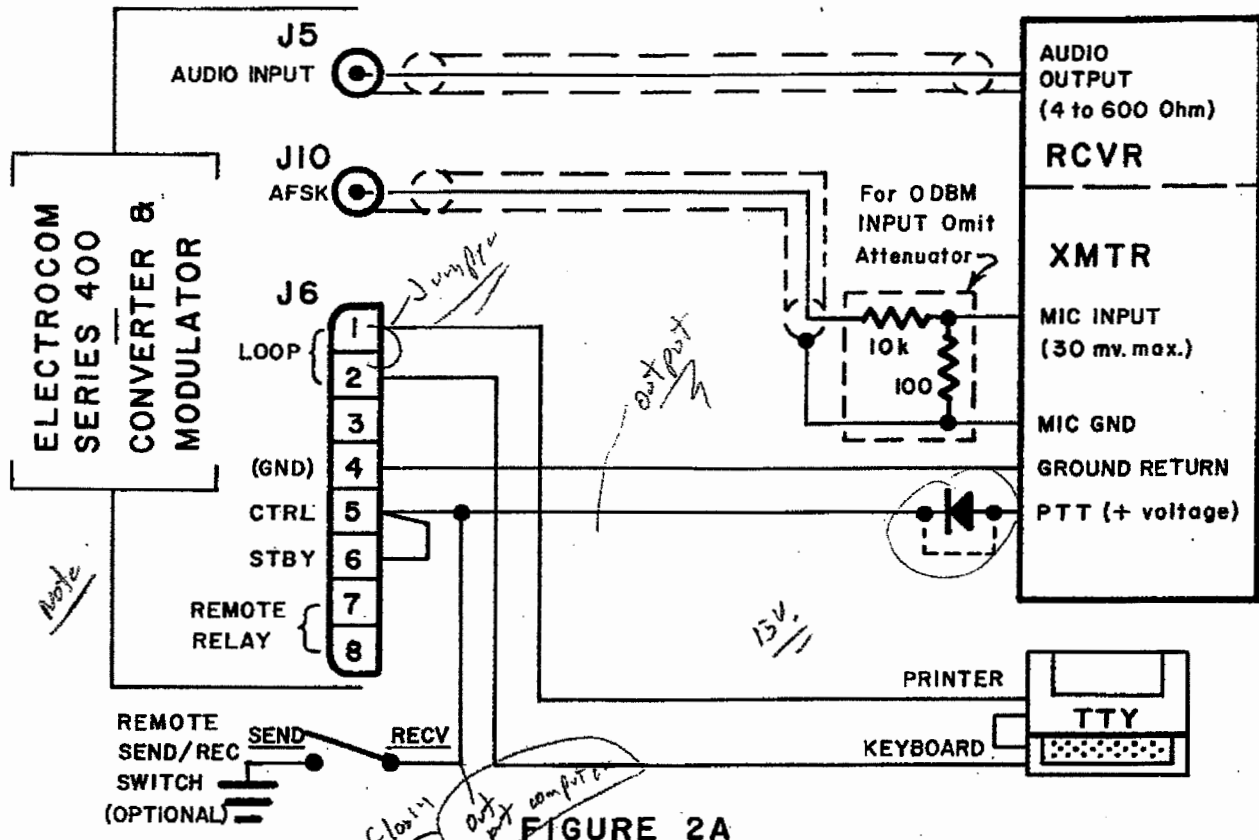


FIGURE 2A

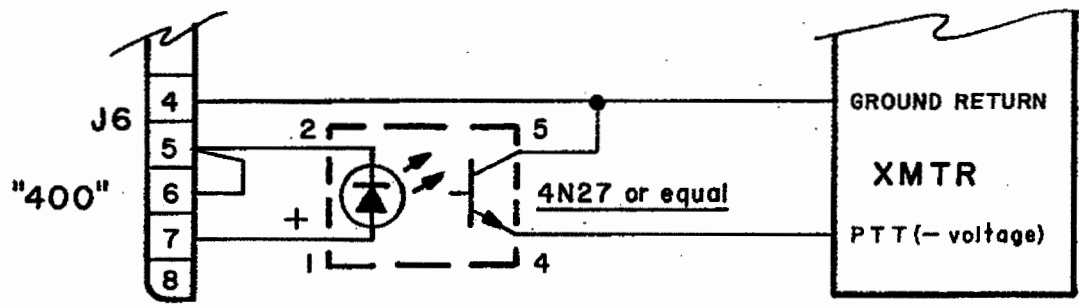
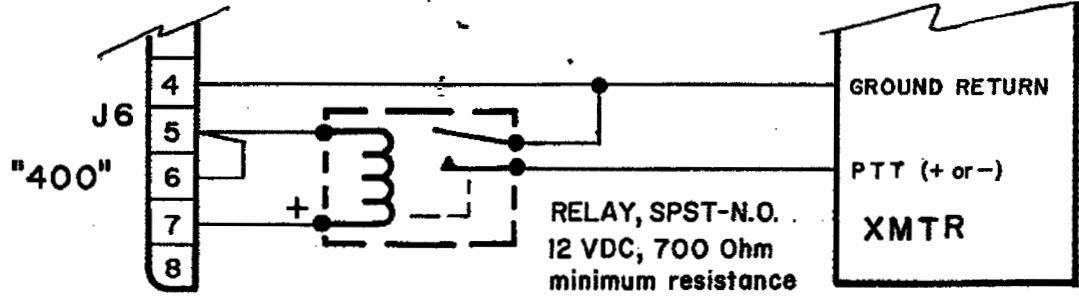


FIGURE 2B

SERIES 400 INTERCONNECTIONS

line operates at negative voltage, this connection must be replaced with an optical isolator or relay as shown in figure 2b.

2.2.4 Remote Standby (STBY)

The keying information for the modulator is derived from the loop circuit of the converter. If an incoming signal is allowed to key the TTY loop, the modulator will regenerate this data. Grounding the remote standby line, J6-6, will cause the converter loop circuit to maintain a steady marking condition. Then only data generated by a TTY machine within the loop will key the modulator. J6-6 may be connected directly to the CTRL terminal J6-5 so that whenever the modulator is sending, the keyer circuit of the converter is locked in a marking condition.

2.2.5 Remote ID (Option)

If this option is installed, a phono jack (J13) is mounted directly above the Key jack. Identification is initiated manually by momentarily grounding this jack while the modulator is sending. If automatic ID control is desired, J11 may be connected to J6-5. Narrow shift Morse code identification will then be transmitted at the beginning and ending of each transmission.

2.3 ALTERNATE MODULATOR KEYING METHODS

Normally the EIA voltage output of the converter supplies data to key the Modulator Card. Since this voltage is keyed by the TTY loop circuit, a teleprinter and keyboard in a series loop connection will simultaneously key the modulator, and provide local copy on the printer. This half duplex connection requires only two wires between the TTY and the 400 (J6-1 & J6-2), and is the most popular configuration.

Provisions for other methods of keying have been included on the 400-800 card which are useful in other applications, or for independent use of the modulator. They are described in the following paragraphs:

* 2.3.1 Loop Input, Half-Duplex

If the EIA or MIL output voltages are required to operate other equipment, interaction of circuits may require using the TTY Loop Option to key the modulator. This configuration requires the addition of CR7, R65, R66 and OC1 to the modulator card. In addition, the following wiring changes will be required in the converter: (1) Remove the wire between J4-4 and J8-19, (2) *Install* remove the green wire from J4-6 and connect it to J8-18, and (3) connect a wire between J4-6 & J8-17. Connect the printer and keyboard in series between terminals J6-1 & J6-2. *jumper - (check Terminals)*

2.3.2 Loop Input, Full-Duplex

The modulator may be keyed from an external "transmit" loop. This will allow completely independent data to be transmitted and received. Add CR7, R65, R66 and OC1 to the Modulator Card. Remove the wire between J4-4 & J8-19. The transmit loop must be connected to J8-17 (-) and J8-18 (+). A two pin connector should be mounted on the rear panel of the 400 and the connections from J8-17 & J8-18 interfaced thru it to the external transmit loop. In this configuration, the printer remains connected to J6-1 & J6-2 while the keyboard connects in series with the external loop connections.

do this
Remove
(Leave in)
Add

do this
omit

Install
phono jack
center of phono connector

2.3.3 Contact Keying, Full-Duplex

Full duplex keying, without the use of another loop supply, may be obtained by keying the modulator from the keyboard contacts while the printer is operating from the loop supply in the converter. This method will also allow the polar options to be used with the printer, together with a neutral or polar keyboard.

2.3.3.1 When the EIA/MIL output is not required in the system, the following modifications are suggested: (1) Remove U4 from the Power/Keyer card, p. n. 400-400, and (2) install R65 (10K, 1/4 wt.) on the Modulator Card, 400-800. The keyboard will then connect between J6-3 & J6-4, and the printer will remain connected between J6-1 & J6-2.

2.3.3.2 If the EIA/MIL output must be retained along with this method of keying, the following modification is required: (1) Remove the wire connecting J4-4 and J8-19, (2) add a phono connector to the rear panel and connect a wire between its center terminal and J8-19, and (3) install R65 on the 400-800 card. Connect the keyboard contacts to the added connector. The loop and EIA/MIL output will operate in their normal manner.

2.3.4 Contact Keying, Half-Duplex

This method allows the keyboard and printer to operate in independent circuits as described in paragraph 2.3.3.1. However, keyboard data will operate the printer and provide local monitoring of the transmitted information. In addition to all modifications described under 2.3.3.1, connect the cathode (banded end) of a 1N4148 diode to the end of R7 nearest C6 on Power/Keyer card 400-400, and the anode to the R15 circuit pad nearest R14. (Do not install R15.) This connection will allow keying of a neutral loop only.

If a polar loop is required, a resistor and a 2N3569 (or similar) transistor must be added to card 400-400. Connect a 100K, 1/4 wt. resistor to the R15 circuit pad instead of the 1N4148 diode. Solder the other end of this resistor to the base of the 2N3569. Solder the 2N3569 collector to the junction of R5 & R16 (feedthru pad directly above C4), and its emitter to ground (end of R6 closest to C4).

2.4 TONE MONITOR OPTION

When the receiver output is muted during transmission, the output tones from the modulator may be monitored on the CRT of the 400 converter. This option requires the installation of a 470K, 1/4 wt. resistor for R93 on Demodulator Card 400-100, and a jumper wire between terminals P8-C & P8-D on the Modulator Card. In addition, the tone monitor connection between the AFSK jack (J10) and Demodulator Card connector J1-2 must be added. The spare green wire which terminates at the cable clamp near J10 is connected to J1-2. When adding this option, splice a short insulated wire between this termination and J10.

SECTION 3, OPERATION

3.1 FRONT PANEL CONTROLS

The following front panel switches on the series 400 converters control modulator operation as follows:

3.1.1 Channel

Positions 1, 1M & 1S select the Channel 1 mark and space tones, and positions 2, 2M & 2S select the Channel 2 mark and space tones. Each of these four tone frequencies must be programmed on the Modulator Card. (See paragraph 3.2.1.)

3.1.2 Keying

This switch selects which tone in a channel pair will represent the mark signal. In all but the REVERSE position, marking data input will produce the mark tone programmed on the Modulator Card, and spacing data will produce the space tone. The REVERSE position inverts these tones, causing marking data to produce the space frequency and spacing data the mark frequency.

3.1.3 Power

Whenever this switch is in the ON or CRT positions operating voltage is applied to the Modulator Card; however, the tone output is muted. When placed in the SEND position tone output is turned on, and control terminal J6-5 is grounded.

3.2 INTERNAL CONTROLS

The controls described in this section do not normally require adjustment after the initial setting. Access is obtained by removing the bottom cover. The locations described are viewed from the front of the unit. All controls are located on the Modulator Card, 400-800. They are shown in Figure 4.

3.2.1 Frequency Adjustments

Each tone frequency is preset internally with a four pole DIP switch and a 25 turn trimmer potentiometer. The trimmer is used to set the frequency after the adjustment range is selected with the DIP switch. Refer to Figure 4 for the location of the various switches and trimmers. They are located towards the front edge of the PC board with the space controls on the left and the mark controls adjacent. Note that each trimmer resistor is closest to the edge of the board with its associated switch directly behind.

The switches provide 16 resistance ranges using a binary coded number. Switch section 1 represents number 1; section 2, number 2; section 3, number 4; and section 4, number 8. Each switch position adds to the number as its actuator is turned on. With all actuators in the "off" position, number zero provides the lowest frequency. As the number is increased until all four actuators are "on" (number 15), the highest frequency range is reached.

To adjust the Channel 1 mark frequency place the Channel selector in position "1", the Keying switch to STANDBY and S2 to the estimated range setting. (See Figure 3.) Connect J6-1 & J6-2 together to provide a marking condition. With a counter or other frequency measuring device connected to the AFSK output, place the Power switch in the SEND position and adjust R42 until the correct frequency is obtained. The frequency is increased as R42 is turned clockwise. If the proper frequency cannot be obtained, increase

**TYPICAL FREQUENCY RANGE FOR
SWITCH SETTINGS ON
MODULATOR CARD, P.N. 400-800**

1 = ON position of switch section; 0 = OFF position of switch section

Binary Number	Switch Section				Approximate Frequency Range
	1 (1)	2 (2)	3 (4)	4 (8)	
15	1	1	1	1	2870 -- 3325 Hertz
14	0	1	1	1	2540 -- 2890
13	1	0	1	1	2285 -- 2560
12	0	0	1	1	2070 -- 2300
11	1	1	0	1	1900 -- 2085
10	0	1	0	1	1750 -- 1905
9	1	0	0	1	1625 -- 1760
8	0	0	0	1	1515 -- 1630
7	1	1	1	0	1420 -- 1520
6	0	1	1	0	1335 -- 1425
5	1	0	1	0	1260 -- 1340
4	0	0	1	0	1195 -- 1265
3	1	1	0	0	1135 -- 1200
2	0	1	0	0	1080 -- 1140
1	1	0	0	0	1030 -- 1085
0	0	0	0	0	985 -- 1035

FIGURE 3

or decrease the number on the switch setting until the proper range is found. The Channel 1 space frequency is adjusted in a similar manner using S3 to set the range and R43 for the adjustment. Open the connection between J6-1 & J6-2 in order to produce a spacing condition.

Channel 2 is adjusted in the same manner by placing the Channel selector in position "2". S4 & R44 adjust the mark frequency, and S1 & R41 adjust the space frequency. Note that these four adjustments are required when the modulator card is assembled to "level 3". When assembled to "level 2" the Channel 2 mark adjustment is common to both channels. When assembled to "level 1", only the Channel 2 adjustments are utilized.

3.2.2 Level

Control R17 which is located to the left of center adjusts the audio output voltage of the modulator. Its range is approximately -4 to +1 dbm. This control is factory set to provide 0 dbm. (1 mv. into a 600 ohm load) at the rear panel AFSK jack.

If the transmitter being fed by the modulator requires less than -4 dbm., an attenuator should be installed at the transmitter input as described in paragraph 2.2.1. When required, a greater range of level adjustment can be provided by replacing resistor R18 with a jumper wire.

3.2.3 Amplitude Adjustment (Option A)

When option A is installed, the amplitude of each tone may be reduced below that set by the Level control. R61 (located above S3) varies the amplitude of the Channel 1 space tone, R64 varies the Channel 1 mark tone, R62 varies the Channel 2 space tone, and R63 varies the Channel 2 mark tone. These adjustments are made only after each frequency is set and the complete transmitting system is operating. The driving or output power of the transmitter must be observed and the individual tone amplitudes adjusted to provide equal output for each frequency. This adjustment will compensate for variations in audio response often present in SSB transmitters.

3.2.4 Null

The Null control R10, located in the upper left area of the card, determines the amount of output tone leakage when the modulator is not sending. To adjust: (1) connect an audio voltmeter to the AFSK output, (2) place the power switch in the ON position, and (3) adjust R10 for minimum voltage reading. When properly adjusted, this output voltage will be less than 10 mv. into a 600 ohm load.

3.3 ON BOARD JUMPERS

3.3.1 Peak or Zero Switching

Without option A, terminals E & F must be jumpered to provide peak waveform switching. U6, C11 & R61 thru R64 are not required. When option A is installed, terminals E & D must be jumpered to provide zero waveform switching. Components R14, R15 & C6 are not required with this option.

The matrix contains 128 positions. However, the first position is reserved as a standby location, and the second thru fourth positions should be left vacant in order for the listener to hear the transition between the TTY and identification codes. The remaining 124 positions are available for programing. If the message is short, leave equal vacant positions at the beginning and end of the program.

Use extreme care when soldering the matrix to avoid permanent damage to the PC board. Remove IC's U9 & U10 while soldering the diodes. Since the solder pads are relatively small, use a pencil type soldering iron having a narrow tip. Fine solder (.032" diameter) should be used sparingly when making the connections.

The ID sequence extends consecutively from matrix position A-4 to H-16. The cathode of each diode (banded end) connects to the lettered line, and the anode connects to the numbered line. Use 1N4148 or 1N914 diodes. Mount them vertically with the top lead bent over and back down to the board. Allow at least 1/32 of an inch between the end of each diode and the PC board. Cut off any excessive lead length after a diode is soldered. A diode soldered in the wrong position can most easily be removed by first cutting its top lead. Then pull each lead out with needle nose pliers while heating its pad. Any solder remaining in the hole can be removed with the end of a toothpick while heating the pad.

NOTE: The location of matrix positions on the Modulator Card is shown in Figure 3. The diodes shown in this figure covering positions A-4 thru A-14 are programed with the letters "DE" (Dash-dot-dot dot). Do not confuse the schematic representation of the matrix with the physical layout as shown in Figure 3.

**TYPICAL FREQUENCY RANGE FOR
SWITCH SETTINGS ON
MODULATOR CARD, P.N. 400-800**

1 = ON position of switch section; 0 = OFF position of switch section

Binary Number	Switch Section				Approximate Frequency Range
	1 (1)	2 (2)	3 (4)	4 (8)	
15	1	1	1	1	2870 -- 3325 Hertz
14	0	1	1	1	2540 -- 2890
13	1	0	1	1	2285 -- 2560
12	0	0	1	1	2070 -- 2300
11	1	1	0	1	1900 -- 2085
10	0	1	0	1	1750 -- 1905
9	1	0	0	1	1625 -- 1760
8	0	0	0	1	1515 -- 1630
7	1	1	1	0	1420 -- 1520
6	0	1	1	0	1335 -- 1425
5	1	0	1	0	1260 -- 1340
4	0	0	1	0	1195 -- 1265
3	1	1	0	0	1135 -- 1200
2	0	1	0	0	1080 -- 1140
1	1	0	0	0	1030 -- 1085
0	0	0	0	0	985 -- 1035

FIGURE 4

3.3.2 CRT on Send

Normally the CRT monitor is disabled when the power switch is placed in the SEND position. The CRT may be left operative during transmission by installing a jumper between points P8-C & D on the modulator card.

3.4 AUTOMATIC ID GENERATOR (OPTIONAL)

Option B provides automatic code identification as described in Section 1.1.

3.4.1 Visual ID Monitor

During transmission, both the "STBY" and "RECV" front panel LED indicators are normally illuminated as described in paragraphs 2.3.7 (pg. 5) and 3.5 (pg. 10) of the Model 400 Instruction Manual. Whenever the automatic ID sequence is initiated the green "RECV" LED extinguishes. As the code is generated this indicator blinks in unison. Upon completion of the ID sequence this LED returns to its normal operating state.

3.4.2 Audible ID Monitor

When option D is installed, a speaker within the converter provides a cw sidetone monitor. Adjust R59 to obtain a comfortable listening level during identification periods.

3.4.3 ID Speed Adjustment

Potentiometer R47 controls the cw keying speed. While monitoring the ID sequence, adjust R47 to the rate desired.

3.4.4 ID Control

Connecting points V & W on Modulator Card 400-800 will cause the ID sequence to automatically trigger at the beginning and ending of each transmission. If option D is installed in the converter, identification may be controlled either manually or automatically as described in paragraph 2.2.5.

NOTE: If connected for automatic operation, turning the power switch of the converter from "off" to "on" will trigger the ID sequence. Therefore, to prevent transmission when initially turning on the converter, turn off power to the transmitter or disable the PTT circuit until this sequence is completed.

3.4.5 Programing Morse Code

In order to allow the code format to be easily programed by the user without special equipment, a diode matrix is used to store the sequence of dots and dashes which will be generated. Each diode will produce a "key down" condition as the matrix is scanned. Since the correct ratio between the Morse code dot and dash is 1 to 3, one diode is installed for each dot and three diodes adjacent to each other are installed for each dash. One vacant space is allowed between the elements of a character, three spaces between each character, and six spaces between each word. Slight variations in dash length and spacing may be used to change the weighting of the code, and extend the message over the entire duration allowed. For example, the spacing between words may be increased to 7 or 8 matrix positions, and the dashes may be extended to 4 diodes.

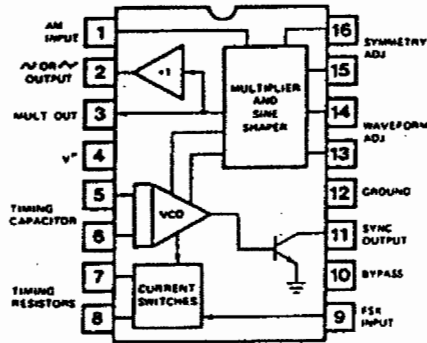
The matrix contains 128 positions. However, the first position is reserved as a standby location, and the second thru fourth positions should be left vacant in order for the listener to hear the transition between the TTY and identification codes. The remaining 124 positions are available for programing. If the message is short, leave equal vacant positions at the beginning and end of the program.

Use extreme care when soldering the matrix to avoid permanent damage to the PC board. Remove IC's U9 & U10 while soldering the diodes. Since the solder pads are relatively small, use a pencil type soldering iron having a narrow tip. Fine solder (.032" diameter) should be used sparingly when making the connections.

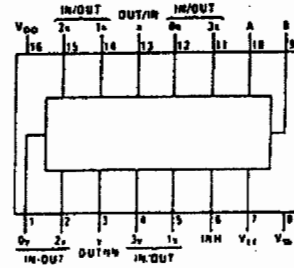
The ID sequence extends consecutively from matrix position A-4 to H-16. The cathode of each diode (banded end) connects to the lettered line, and the anode connects to the numbered line. Use 1N4148 or 1N914 diodes. Mount them vertically with the top lead bent over and back down to the board. Allow at least 1/32 of an inch between the end of each diode and the PC board. Cut off any excessive lead length after a diode is soldered. A diode soldered in the wrong position can most easily be removed by first cutting its top lead. Then pull each lead out with needle nose pliers while heating its pad. Any solder remaining in the hole can be removed with the end of a toothpick while heating the pad.

NOTE: The location of matrix positions on the Modulator Card is shown in Figure 4. The diodes shown in this figure covering positions A-4 thru A-14 are programed with the letters "DE" (Dash-dot-dot dot). Do not confuse the schematic representation of the matrix with the physical layout as shown in Figure 4.

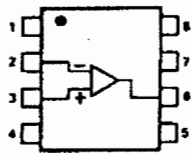
SEMICONDUCTOR PIN ARRANGEMENTS



XR 2206



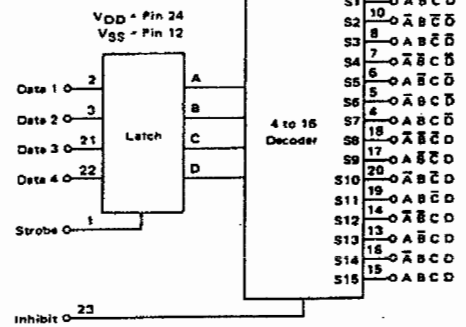
(CD) 4052
(MC) 14052



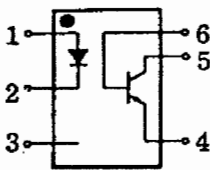
1. Freq. Comp. A/ Offset Null.
2. Inverting Input
3. Noninverting Input
4. V⁻
5. Offset Null
6. Output
7. V⁺
8. Freq. Comp. B

748CN

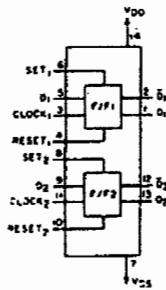
**4-BIT LATCH/4-TO-16
LINE DECODER**



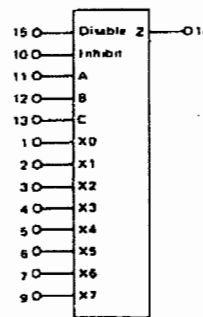
(CD) 4514
(MC) 14514



4N27

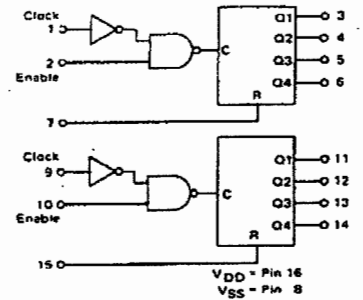


(CD) 4013
(MC) 14013



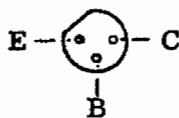
8-CHANNEL DATA SELECTOR

(CD) 4512
(MC) 14512



DUAL BINARY UP COUNTER

(CD) 4520
(MC) 14520



2N3569

NOTE: Top view shown on all devices

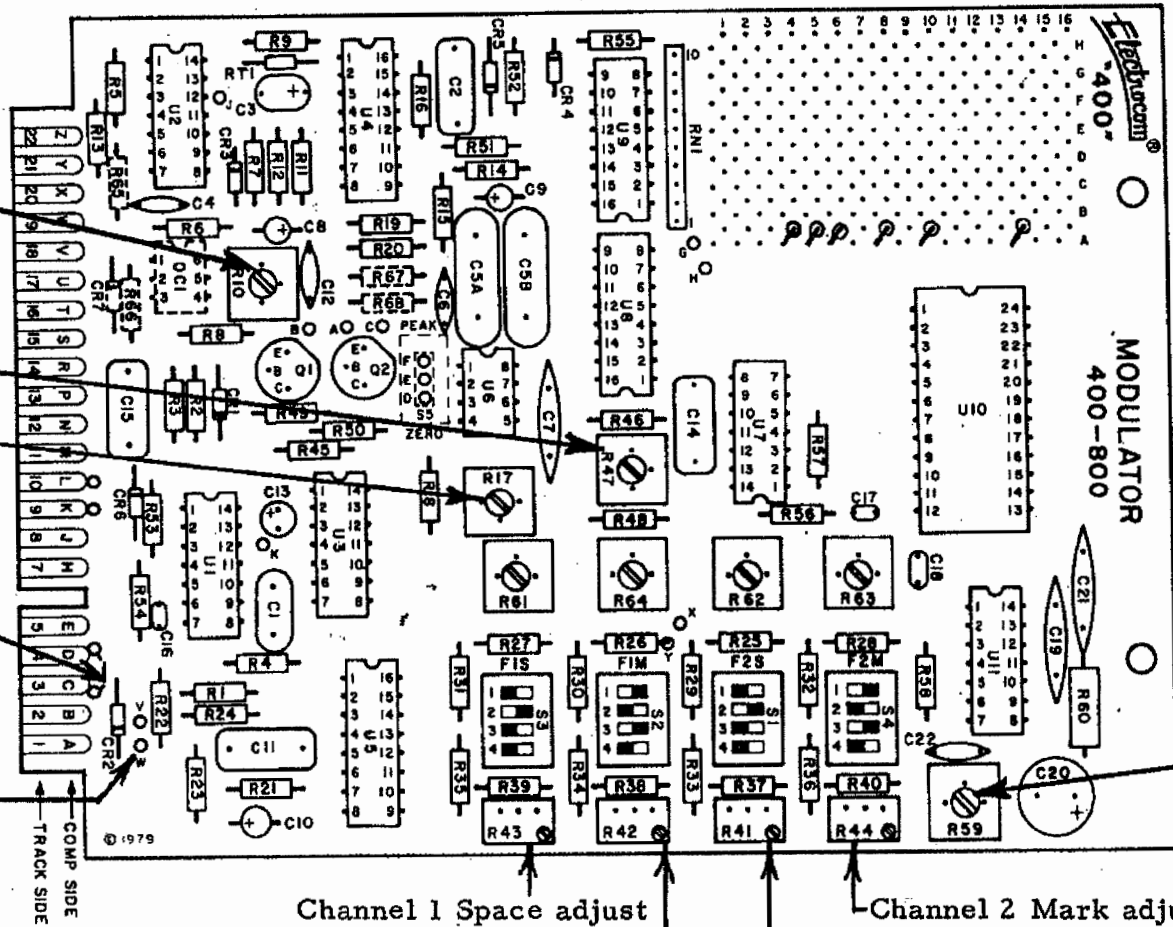
"Null" -- adjust for minimum AFSK output when power switch is in the "ON" position.

ID speed adjustment

R17 - Output level. Adjust with power switch in "Send" position.

Jumper C & D to provide CRT operation during send condition

Jumper "V" & "W" for automatic ID control



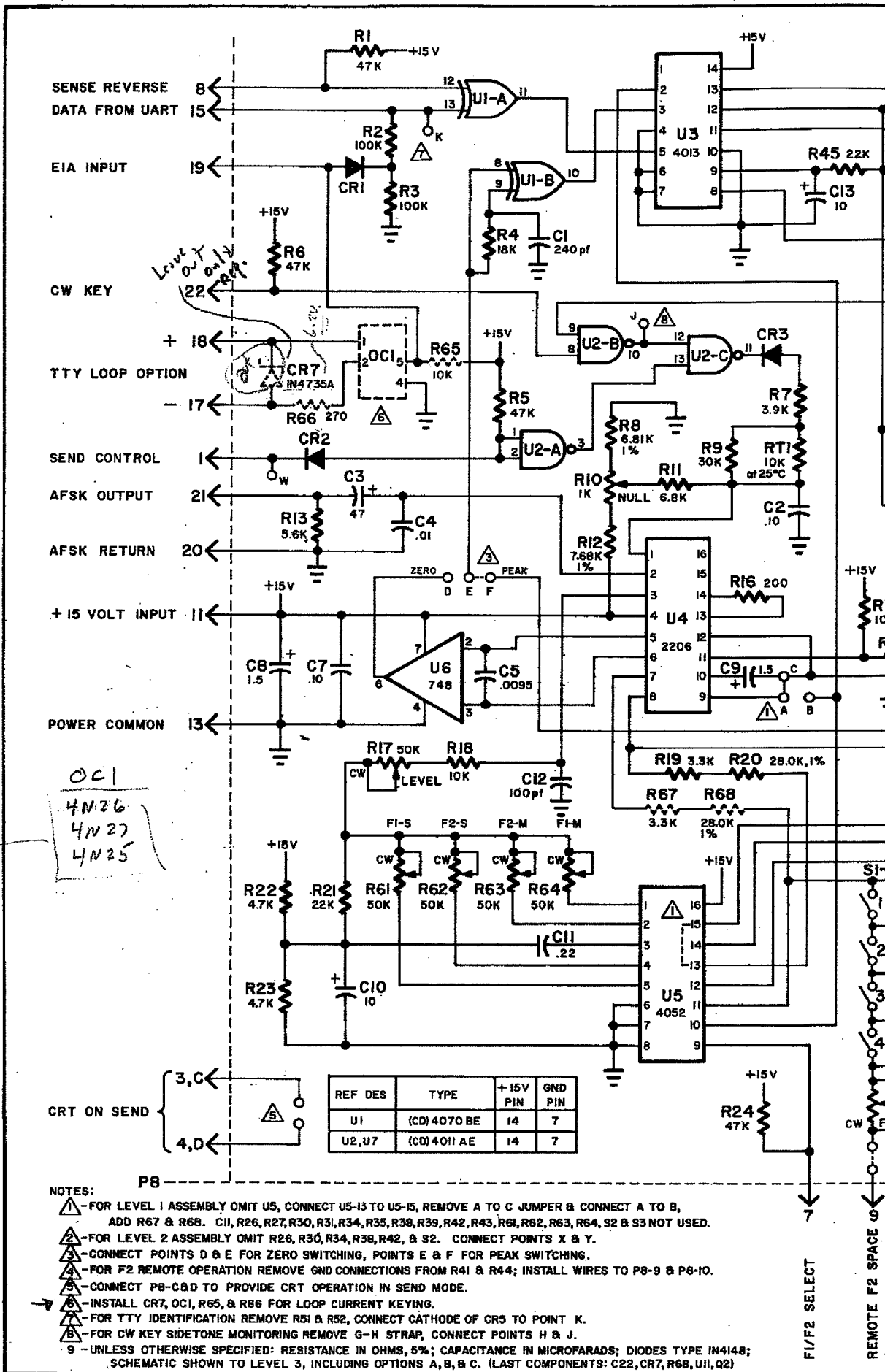
CW sidetone volume adjust

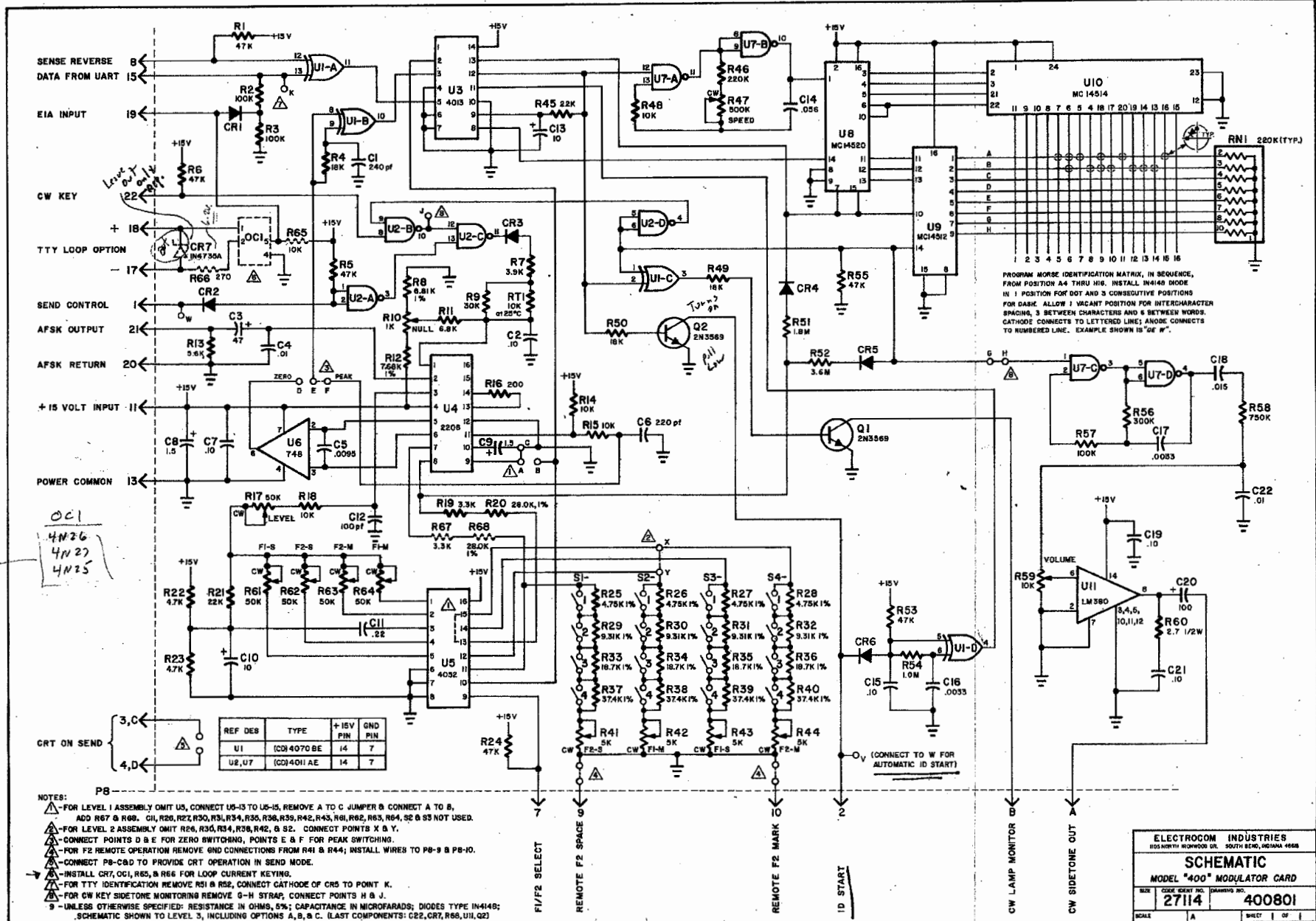
Channel 1 Space adjust
Channel 1 Mark adjust

Channel 2 Mark adjust
Channel 2 Space adjust

FIGURE 4

COMPONENT LOCATION & ADJUSTMENTS, MODULATOR CARD P.N. 400-800





PROGRAM MORSE IDENTIFICATION MATRIX, IN SEQUENCE, FROM POSITION A4 THRU H16. INSTALL IN-H48 MODE IN 1 POSITION FOR DOT AND 3 CONSECUTIVE POSITIONS FOR DASH. ALLOW 1 VACANT POSITION FOR INTERCHARACTER SPACING, 3 BETWEEN CHARACTERS AND 6 BETWEEN WORDS. CATHODE CONNECTS TO LETTERED LINE; ANODE CONNECTS TO NUMBERED LINE. EXAMPLE SHOWN IS "W".

REF DES	TYPE	+15V PIN	GND PIN
U1	(C)4070 BE	14	7
U2, U7	(C)4014 AE	14	7

- NOTES:
- ▲ FOR LEVEL 1 ASSEMBLY OMIT U5, CONNECT U5-13 TO U5-15, REMOVE A TO C JUMPER & CONNECT A TO B, ADD R67 & R68. C11, R26, R27, R30, R31, R34, R36, R38, R39, R42, R43, R61, R62, R63, R64, S2 & S3 NOT USED.
 - ▲ FOR LEVEL 2 ASSEMBLY OMIT R26, R34, R38, R42, & S2. CONNECT POINTS X & Y.
 - ▲ CONNECT POINTS D & E FOR ZERO SWITCHING, POINTS E & F FOR PEAK SWITCHING.
 - ▲ FOR F2 REMOTE OPERATION REMOVE GND CONNECTIONS FROM R41 & R44; INSTALL WIRES TO PB-9 & PB-10.
 - ▲ CONNECT PB-C&D TO PROVIDE CRT OPERATION IN SEND MODE.
 - ▲ INSTALL CR7, OC1, R65, & R66 FOR LOOP CURRENT KEYING.
 - ▲ FOR TTY IDENTIFICATION REMOVE RN1 & R56, CONNECT CATHODE OF CR5 TO POINT X.
 - ▲ FOR CW KEY SIDETONE MONITORING REMOVE Q-H SYMB, CONNECT POINTS H & J.
 - ▲ UNLESS OTHERWISE SPECIFIED: RESISTANCE IN OHMS, 5%; CAPACITANCE IN MICROFARADS; DIODES TYPE IN-4145; SCHEMATIC SHOWN TO LEVEL 3, INCLUDING OPTIONS A, B, & C. (LAST COMPONENTS: C22, CR7, R66, U1, Q2)

ELECTROCOM INDUSTRIES
 1801 NORTH WISCONSIN ST., SOUTH BEND, INDIANA 46604

SCHEMATIC

MODEL "400" MODULATOR CARD

SIZE CODE IDENT NO. DRAWING NO.
 27114 400801

SCALE A SHEET 1 OF 1

SERVICE PARTS LIST

When ordering service parts from the factory, it is advisable that both the item number and the Electrocom part number be given. This information will assure that the most suitable component is supplied in the event of an engineering change. All of the 1/4 and 1/2 watt resistors described as fixed composition units may be either of the molded or carbon film types.

For simplification of this parts list and legends, all resistors, capacitors, integrated circuits and transistors on the printed circuit cards are numbered 1 through 99. When describing these parts with respect to the complete converter assembly, add the

printed circuit card number to the item number. For example: Resistor R5 on the main frame should be described as R5, while R5 on the Modulator Card 400-800 should be R805, etc.

An asterisk (*) after an item number refers to the following notations:

- (*1) Used only with zero switching Option A.
- (*2) Used only with current keying option.
- (*3) Used only on level 1 assembly.
- (*4) Used only with automatic ID, Option B.
- (*5) Used only with sidetone monitor, Option D.

MODULATOR CARD, P. N. 400-800 (Schematic 400801)

ITEM	DESCRIPTION	ELECTROCOM PART NO.	ITEM	DESCRIPTION	ELECTROCOM PART NO.
C1	Capacitor, dipped mica, 240 pf. ±5%, 100 v.	2112401	R6	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347
C2	Capacitor, metalized mylar, .10 mfd. ±10%, 100 v.	2341001	R7	Resistor, fixed c.f., 3.9K ohm, 5%, 1/4 wt.	3221239
C3	Capacitor, tantalum, 47 mfd. ±10%, 10 v.	2864701	R8	Resistor, fixed metal film, 6.81K ohm, 1% 1/4 wt.	3311681
C4	Capacitor, disc ceramic, .01 mfd., ±20%, 16 v.	2431002	R9	Resistor, fixed comp., 30K ohm, 5%, 1/4 wt.	3121330
C5	Capacitor assembly, dipped mica, .0095 mfd. ±5%, 100 v.	2129501	R10	Resistor, variable cermet, 1.0K ohm, 10%, 1/2 wt.	3621001
C6	Capacitor, disc ceramic, 220 pf. ±10%, 1 Kv.	2412201	R11	Resistor, fixed comp., 6.8K ohm, 5%, 1/4 wt.	3121268
C7	Capacitor, disc ceramic, .10 mfd. ±20%, 25 v.	2441001	R12	Resistor, fixed m.f., 7.68K ohm, 1%, 1/8 wt.	3311768
C8	Capacitor, tantalum, 1.5 mfd. ±10%, 25 vdc.	2851501	R13	Resistor, fixed comp., 5.6K ohm, 5%, 1/4 wt.	3121256
C9	Capacitor, tantalum, 1.5 mfd. ±10%, 25 vdc.	2851501	R14	Resistor, fixed comp., 10K ohm, 5%, 1/4 wt.	3121310
C10	Capacitor, tantalum, 10 mfd. ±20%, 10 vdc.	2861001	R15	Resistor, fixed comp., 10K ohm, 5%, 1/4 wt.	3121310
C11(*1)	Capacitor, metalized mylar, .22 mfd. ±10%, 100 v.	2342201	R16	Resistor, fixed comp., 200 ohm, 5%, 1/4 wt.	3121120
C12	Capacitor, dipped mica, 100 pf. ±5%, 100 v.	2111001	R17	Resistor, variable cermet, 50K ohm, 10%	3635001
C13(*4)	Capacitor, tantalum, 10 mfd. ±20%, 10 vdc.	2861001	R18	Resistor, fixed comp., 10K ohm, 5%, 1/4 wt.	3121310
C14(*4)	Capacitor, metalized mylar, .056 mfd. ±10%, 100 v.	2335601	R19	Resistor, fixed c.f., 3.3K ohm, 5%, 1/4 wt.	3221233
C15(*4)	Capacitor, metalized mylar, .10 mfd. ±10%, 100 v.	2341001	R20	Resistor, fixed m.f., 28.0 ohm, 1%, 1/8 wt.	3312280
C16(*4)	Capacitor, mylar, .0033 mfd. ±10%, 50 v.	2323301	R21	Resistor, fixed comp., 22K ohm, 5%, 1/4 wt.	3121322
C17(*5)	Capacitor, mylar, .0033 mfd. ±10%, 50 v.	2323301	R22	Resistor, fixed comp., 4.7K ohm, 5%, 1/4 wt.	3121247
C18(*5)	Capacitor, mylar, .015 mfd. ±10%, 50 v.	2331501	R23	Resistor, fixed comp., 4.7K ohm, 5%, 1/4 wt.	3121247
C19(*5)	Capacitor, disc ceramic, .10 mfd. ±20%, 25 v.	2441001	R24	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347
C20(*5)	Capacitor, electrolytic, 100 mfd. —10+100% 16 v.	2571001	R25	Resistor, fixed m.f., 4.75K ohm, 1%, 1/8 wt.	3311475
C21(*5)	Capacitor, disc ceramic, .10 mfd. ±20%, 25 v.	2441001	R26	Resistor, fixed m.f., 4.75K ohm, 1%, 1/8 wt.	3311475
C22(*5)	Capacitor, disc ceramic, .01 mfd., ±20%, 16 v.	2431002	R27	Resistor, fixed m.f., 4.75K ohm, 1%, 1/8 wt.	3311475
CR1 thru CR3	Diode, silicon, 10 ma., 75 piv. (type 1N4148)	1141481	R28	Resistor, fixed m.f., 4.75K ohm, 1%, 1/8 wt.	3311475
CR4(*4)	Diode, silicon, 10 ma., 75 piv. (type 1N4148)	1141481	R29	Resistor, fixed m.f., 9.31K ohm, 1%, 1/8 wt.	3311931
CR5(*4)	Diode, silicon, 10 ma., 75 piv.	1141481	R30	Resistor, fixed m.f., 9.31K ohm, 1%, 1/8 wt.	3311931
CR6(*4)	Diode, silicon, 10 ma., 75 piv.	1141481	R31	Resistor, fixed m.f., 9.31K ohm, 1%, 1/8 wt.	3311931
CR7(*2)	Diode, zener, 6.2 v., 1 wt. (type 1N4735A)	1247351	R32	Resistor, fixed m.f., 9.31K ohm, 1%, 1/8 wt.	3311931
OC1(2*)	Optical coupler, 1500 vdc isolation, (type 4N27)	1400271	R33	Resistor, fixed m.f., 18.7K ohm, 1%, 1/8 wt.	3312187
Q1(*4)	Transistor, silicon, NPN (type 2N3569)	1535691	R34	Resistor, fixed m.f., 18.7K ohm, 1%, 1/8 wt.	3312187
Q2(*4)	Transistor, silicon, NPN (type 2N3569)	1535691	R35	Resistor, fixed m.f., 18.7K ohm, 1%, 1/8 wt.	3312187
R1	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347	R36	Resistor, fixed m.f., 18.7K ohm, 1%, 1/8 wt.	3312187
R2	Resistor, fixed comp., 100K ohm, 5%, 1/4 wt.	3121410	R37	Resistor, fixed m.f., 37.4K ohm, 1%, 1/8 wt.	3312374
R3	Resistor, fixed comp., 100K ohm, 5%, 1/4 wt.	3121410	R38	Resistor, fixed m.f., 37.4K ohm, 1%, 1/8 wt.	3312374
R4	Resistor, fixed comp., 18K ohm, 5%, 1/4 wt.	3121318	R39	Resistor, fixed m.f., 37.4K ohm, 1%, 1/8 wt.	3312374
R5	Resistor, fixed comp., 47K ohm, 5%, 1/4 wt.	3121347	R40	Resistor, fixed m.f., 37.4K ohm, 1%, 1/8 wt.	3312374
			R41	Resistor, variable cermet, 5K ohm, 10%, 20 t.	3625002
			R42	Resistor, variable cermet, 5K ohm, 10%, 20 t.	3625002
			R43	Resistor, variable cermet, 5K ohm, 10%, 20 t.	3625002
			R44	Resistor, variable cermet, 5K ohm, 10%, 20 t.	3625002

Modulator Card, continued

ITEM	DESCRIPTION	ELECTROCOM PART NO.
R45	Resistor, fixed comp., 22K ohm, 5%, ¼ wt.	3121322
R46(*4)	Resistor, fixed comp., 220K ohm, 5%, ¼ wt.	3121422
R47(*4)	Resistor, variable cermet, 500K ohm, 10%, ½ wt.	3645001
R48(*4)	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310
R49(*4)	Resistor, fixed comp., 18K ohm, 5%, ¼ wt.	3121318
R50(*4)	Resistor, fixed comp., 18K ohm, 5%, ¼ wt.	3121318
R51(*4)	Resistor, fixed comp., 1.8 Megohm, 5%, ¼ wt.	3121518
R52(*4)	Resistor, fixed comp., 3.6 Megohm, 5% ¼ wt.	3121536
R53	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
R54	Resistor, fixed comp., 1.0Megohm, 5%, ¼ wt.	3121510
R55	Resistor, fixed comp., 47K ohm, 5%, ¼ wt.	3121347
R56(*5)	Resistor, fixed comp., 300K ohm, 5%, ¼ wt.	3121430
R57(*5)	Resistor, fixed comp., 100K ohm, 5%, ¼ wt.	3121410
R58(*5)	Resistor, fixed comp., 750K ohm, 5%, ¼ wt.	3121475
R59(*5)	Resistor, variable cermet, 10K ohm, 10%, ½ wt.	3631001
R60(*5)	Resistor, fixed comp., 2.7 ohm, 5%, ½ wt.	3131003
R61(*1)	Resistor, variable cermet, 50K ohm, 10%	3635001
R62(*1)	Resistor, variable cermet, 50K ohm, 10%	3635001
R63(*1)	Resistor, variable cermet, 50K ohm, 10%	3635001
R64(*1)	Resistor, variable cermet, 50K ohm, 10%	3635001
R65(*2)	Resistor, fixed comp., 10K ohm, 5%, ¼ wt.	3121310

ITEM	DESCRIPTION	ELECTROCOM PART NO.
R66(*2)	Resistor, fixed comp., 270 ohm, 5%, ¼ wt.	3121127
R67(*3)	Resistor, fixed c.f., 3.3K ohm, 5%, ¼ wt.	3221233
R68(*3)	Resistor, fixed m.f., 28.0 ohm, 1%, ¼ wt.	3312280
RN1(*4)	Resistor network, 9 x 220K ohm, SIP	3642201
RT1	Thermistor, 10K ohm at 25°C., PTC	3831001
S1	4 circuit DIP switch	440041
S2	4 circuit DIP switch	440041
S3	4 circuit DIP switch	440041
S4	4 circuit DIP switch	440041
U1	Integrated circuit, Exc. OR Gate, type 4070	1440701
U2	Integrated circuit, quad 2-NAND gate, type 4011CN	1440111
U3	Integrated circuit, Dual D F.F., type 4013	1440131
U4	Integrated circuit, monolithic function generator, type 2206CP	1422062
U5	Integrated circuit, Dual Mux., type 4052	1440521
U6(*1)	Integrated circuit, Op. Amp., type 748	1407481
U7(*4)	Integrated circuit, quad 2-NAND gate, type 4011CN	1440111
U8(*4)	Integrated circuit, Dual Up Counter, type 4520	1445201
U9(*4)	Integrated circuit, 8 Ch. Selector, type 4512	1445121
U10(*4)	Integrated circuit, Decoder, type 4514	1454141
U11(*5)	Integrated circuit, Amplifier, type LM380	1403801

Electrocom[®] INDUSTRIES

Communications Products and Systems

1105 NORTH IRONWOOD DRIVE, SOUTH BEND, INDIANA 46615

PRODUCT DESCRIPTION ELECTROCOM[®] ACCESSORY CARD, P. N. 400-900

The Electrocom[®] Accessory Card, p. n. 400-900, contains several features which enhance radio-teletypewriter system performance. This card is designed for installation within the "Series 400" Frequency Shift Converters thru a dual 22 pin edge card connector. It provides the following features: (1) Signal regeneration and/or speed conversion, (2) automatic polarity sensing, (3) selective calling, and (4) idle line motor control. Operating voltages are obtained from the regulated power supply within the converter. The various functions of the Accessory Card are described in the following paragraphs.

(1) Signal Regenerator

The signal regenerator accepts Baudot code rates of 45, 50, 57 and 75 bauds (60, 66, 75 & 100 wpm respectively) and an ASCII rate of 110 bauds (100 wpm). This circuit utilizes a Universal Asynchronous Receiver/Transmitter (UART) integrated circuit to retime the data and generate an optimum signal to the teleprinter, regardless of large amounts of bias which may exist on the incoming signal. Independent input and output UART clocks may be utilized to provide speed conversion. For example: the output clock may be set for 75 baud Baudot operation in order to feed a teleprinter geared for this speed. The input clock frequency may be selected to receive data at 45, 50, 57 or 75 baud Baudot code. Upon regeneration, a properly timed 75 baud signal will be presented to the teleprinter. When speed conversion is utilized, the teleprinter speed must always be equal or greater than the incoming speed to prevent loss of characters.

When both signal regeneration and speed conversion features are desired, a concentric "Baud" switch assembly is installed on the converter. The outer knob selects the incoming data speed and the frequency response of the baud rate filter. The inner knob switches the regenerator on, selects the outgoing speed to the teleprinter, and selects Baudot or ASCII operation. If speed conversion capability is not desired, the inner knob assembly may be omitted and the regenerator will be placed into operation whenever the keying switch on the converter is in the "Mark, Auto, or SC" positions.

(2) Automatic Polarity Sensing

Automatic sensing of data polarity is enabled whenever the "Keying" switch is in the "Auto" or "SC" positions. This circuit senses the mark and space polarity of the incoming data to determine if it is correct for the code selected. If incorrect, the keying polarity will automatically reverse. Reversal is indicated by a front panel LED indicator which is located beneath the "Reverse" position of the keying switch.

(3) Selective Calling

The autostart feature contained in the Series 400 converters turns the TTY motor on whenever valid information exists. If several systems are monitoring the same radio channel, all teleprinters will operate. Selective Calling (Selcall) operates in conjunction with the autostart circuit to control the teleprinter only upon receipt of a predetermined sequence of characters.

The Selcall "turn on" code may be programmed with any sequence containing two thru nine characters. In a similar manner, the "turn off" code may be programmed with any sequence from two thru six characters. If a turn off sequence is not received, the Selcall will automatically reset when the autostart circuit turns off the teleprinter motor. These sequences may use either Baudot or ASCII code. They are easily programmed by the customer without special equipment.

Selcall operation is enabled by an added switch position adjacent to the "Auto" position on the keying selector. The legend used for this position is "SC".

(4) Idle Line Motor Control

The autostart circuitry turns the TTY motor off whenever a steady space tone or absence of signal exists for 50 seconds. However, if data transmission ceases yet a continuous mark tone remains, the motor will continue to operate. The Idle Line Control will turn the motor off after a continuous 50 second marking period. The motor will remain off until data transmission resumes. This circuit has been designed to prevent false motor starts during signal fading so often encountered on HF radio paths.

Idle line control is independent of Selcall control and will not reset the Selcall circuit. Therefore, data will be received when transmission resumes regardless if the system is operating in the Autostart or Selcall modes.

Additional mainframe wiring is required to support Accessory Card operation. We suggest that Series 400 converters be returned for factory modification if this card is added. All standard features of the converter remain unchanged if the Accessory Card is not installed. Inserting the card into its edge card connector activates the accessory features.

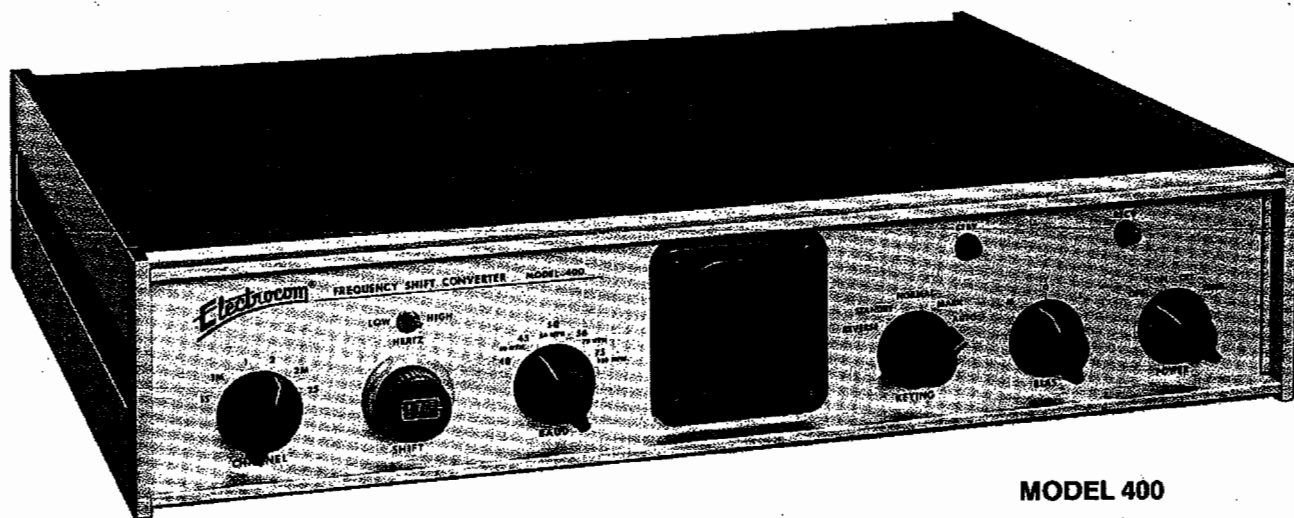
When both the Modulator and Accessory cards are installed in a Series 400 converter, the signal to be transmitted will also be regenerated. If speed conversion is utilized, the input and output clocks will reverse during transmission. Thus, the higher speed TTY machine may be used to transmit data at the same baud rate as that being received; however, the TTY operator must limit his typing speed so as not to exceed the lower transmission speed.

Electrocom[®]
INDUSTRIES

Communications Equipment and Components

FREQUENCY SHIFT CONVERTERS

MODELS 400 and 402

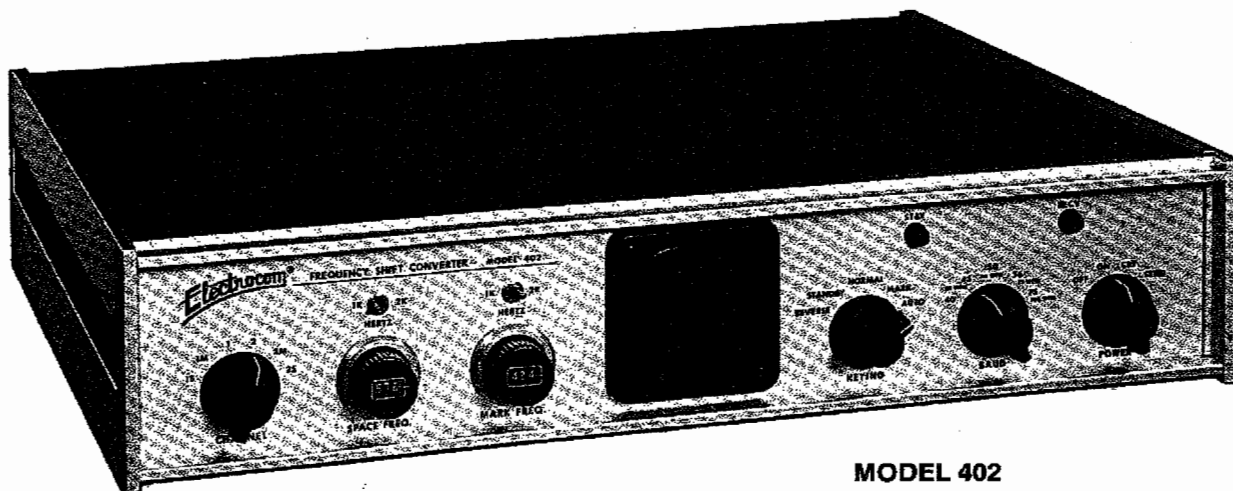


MODEL 400

HIGHLY VERSATILE, COMPLETE TERMINAL UNITS FOR OUTSTANDING RADIO-TELETYPEWRITER PERFORMANCE

FEATURES:

- Continuously variable shift
- Matched precision filters and Baud Rate selector provide optimum performance for each data rate
- Semi-diversity and mark or space only operation assist during selective fading and interference
- Audio filter system—compatible with FSK and AFSK operation
- 2 inch scope monitor allows rapid, precise receiver tuning
- Built in Autostart, Mark-hold, and Antispace operation
- Ultrasonic high voltage CRT supply provides sharp, bright, and uniform scope presentation over full range of line voltage
- Monitor may be switched off to conserve power during unattended operation
- Loop supply maintains constant current over wide range of loop resistance and line voltage. Current continuously variable from 20 thru 60 ma.
- Mark/Space "Bias" control aids in correcting distorted incoming signals. Detent accurately locates zero bias. (Model 400)
- LED indicators show "Standby, Receive, and Send" logic states
- Station control contacts provided on power switch
- EIA or MIL output voltage levels for operating external keyers or video displays
- A reputation for outstanding performance, high reliability and quality construction, established by Electrocom[®] over more than 17 years, is maintained by conservative design and quality components throughout.



MODEL 402

DESCRIPTION:

The Electrocom® Models 400 and 402 are completely self-contained Frequency Shift Converters (Demodulators) designed primarily for FSK reception on high frequency radio channels. Since this mode of operation requires the most stringent performance capabilities, these units are equally well suited for vhf or microwave applications. Joining earlier Electrocom® equipment, in use worldwide for military, government, commercial and amateur applications, the "400" series adds new dimensions of compatibility between radio and teletypewriter systems. These converters are ideal for continuous unattended monitoring, since "Autostart" circuitry turns the teleprinter motor on when valid teletype signals appear. The motor turns off after message completion, but loop current is maintained until the machine quietly stops. Afterwards, this current turns off to provide minimum standby power. Connections to the audio output of a communications receiver and to the teleprinter are the only requirements for installation. Rear panel terminals allow remote motor control, standby, station control, and F. S. Keyer interfacing, while an AC receptacle provides switched power for local printer motor control. Provisions have been included in the basic design for the internal addition of various accessories such as electronic signal regeneration, speed conversion, selective teleprinter motor control (Selcall), idle line motor control, and a frequency shift modulator (tone keyer) for use in the transmission of RTTY signals.

The Model 400 is normally used with variable frequency receivers which can be adjusted to produce a 2125 Hz. mark tone. The Model 402 was designed for use primarily with crystal controlled, synthesized, or tone modulated receivers where the converter must be matched to the existing tone frequencies. Tone discrimination is accomplished by identical optimum bandwidth mark and space filters. Two channels, each accepting individual mark and space frequencies, are immediately available by switch selection. Channel 1 of either model may be preset internally anywhere in the range from 1000 to 3200 Hz., thereby accommodating shifts from less than 50 to over 2000 Hz. Channel 2 in the Model 400 has a preset mark frequency and a continuously variable space frequency which is controlled by a front panel knob. This knob presents an in-line three digit display of the amount of shift and is accurately calibrated in Hertz. Ten revolutions linearly cover the range from 0 to 1000 Hz., readable to within 1 Hz. A ranging switch above this knob allows the space frequency to be positioned above or below the mark frequency, thereby allowing the Model 400 to be used with restricted bandwidth SSB receivers as well as with conventional tone systems. The Model 402 differs from the Model 400 in that it contains two variable front panel knobs for setting the Channel 2 mark and space frequencies. Each of these knobs with its associated switch covers the complete range from 1000 to 3000 Hz. The front panel "Bias" control has been omitted on the Model 402; however, an internal control allows system bias compensation if necessary. All other features of the Models 400 and 402 are identical.

Ultimate long term stability and high selectivity, characteristics seldom obtained with less expensive R-C filter networks, are achieved by the use of precision tuned, temperature compensated, L-C networks. The system calibration accuracy combined with the sharp, straight line monitor display allows frequency shift measurement of associated transmitting equipment. Normal and reverse sense, standby, mark-hold, and autostart modes are conveniently programmed from the keying selector switch. C-mos logic provides low power consumption with high noise immunity. Zero crossing solid-state motor switching eliminates maintenance normally required with mechanical relays. Other features include linear full wave precision detectors, a dynamic range greater than 60 db., decision hysteresis and automatic waveform symmetry correction. With the exception of the CRT used for the monitor display, all circuitry is solid-state. Monitor visibility is improved and CRT life extended by automatic intensity control circuitry which adjusts trace brightness in proper contrast to ambient light, and by automatic blanking during signal absence. In addition to the many deluxe standard features, various options are available which further increase this equipment's versatility. For example, the Power/Keyer card may be adapted to polar current output, and a switchable input filter assembly can be installed within the cabinet.

Each Model 400 or 402 is attractively packaged in a functional cabinet ruggedly constructed from aluminum extrusions. Modular circuitry is contained on four plug-in printed circuit cards: the Demodulator, Logic, Monitor, and Power/Keyer. Additional space is allocated for Accessory and Modulator cards. These cards are

manufactured from epoxy glass material, have plated through holes and gold plated edge card connections in order to provide the highest reliability. They are mechanically positioned so that complete access to all test points and calibration adjustments is readily available by removing the cabinet covers. As a result, card extenders or other special fixtures are not required for servicing. Exact, detailed professional design has produced the Electrocom® Series 400 Frequency Shift Converters not only for today's communication environment, but ultimately to fulfill radio-teletypewriter requirements for years to come.

SPECIFICATIONS:

INPUT IMPEDANCE: 600 ohm, unbalanced. Option #3, balanced input

SENSITIVITY: Threshold 1 mv., full limiting 5 mv.

INPUT DYNAMIC RANGE: -50 to +20 dbm.

SHIFT: Continuously variable from 50 to 1000 Hz. (400), 50 to 2000 Hz. (402), and preset from 50 to 2200 Hz.

tone frequencies:

CHANNEL #1: Mark and Space frequencies internally adjustable from 1000 to 3200 Hz.

CHANNEL #2 (Model 400): Mark, 2125 Hz.; Space (LOW), 2125 to 1125 Hz.; Space (HIGH), 2125 to 3125 Hz.

CHANNEL #2 (Model 402): Mark and Space frequencies independently variable from 1000 to 3000 Hz.

CALIBRATION ACCURACY: ± 12 Hz. of reading

MARK & SPACE FILTER SELECTIVITIES: 95 ± 10 Hz. at 3 db.

MONITOR/TUNING INDICATOR: 2 inch CRT

RESPONSE TIME (NOMINAL): Mark-hold, 1.3 seconds; Autostart, 3.8 seconds; Motor turn off delay, 50 seconds

MAXIMUM KEYING RATE: 75 bauds (100 wpm, 5 level Baudot code). Option #6, 110 bauds (100 wpm, 8 level ASCII code).

CURRENT OUTPUT: Neutral DC continuously variable from 20 thru 60 ma. into any loop resistance from 0 to 1500 ohms. Current will remain constant regardless of loop resistance or power line voltage variations. Maximum resistance for 20 ma. loop is 5000 ohms. See Options #4 & #5 for polar current output.

VOLTAGE OUTPUT: EIA RS232C (-14 v. mark, +14 v. space), or MIL STD 188C (+6 v. mark, -6 v. space).

POWER: 115 or 230 v. $\pm 15\%$ (rear panel switch selected), 50-400 Hz. 10 watts standby power with CRT off, 40 watts maximum

OPERATING TEMPERATURE: 0 to 65°C. (32 to 149°F.)

PANEL: Clear anodized, etched aluminum finish with black figures

CASE: Aluminum with clear anodized finish, textured dark grey covers and trim

DIMENSIONS: 89 mm. (3.5 inches) high, 432 mm. (17 in.) wide, 356 mm. (14 in.) overall depth. Rack mounted model, Option #1, extends 327 mm. (12.875 in.) behind and 45 mm. (1.75 in.) forward of rack mounting surface. Panel width is 483 mm. (19 in.)

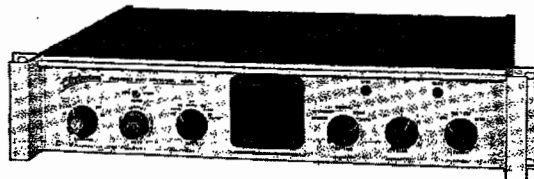
WEIGHT (less options): 6.01 Kg. (13.25 lbs.) net; 7.5 Kg. (16.6 lbs.) packed for domestic shipment, suitable for air transportation overseas.

OPTIONS AVAILABLE:

OPTION #1 - Rack mounting adapter with handles. Normally supplied factory installed, but may be installed in the field.

OPTION #2 - Input filter and preamplifier assembly, less filters. The use of an optional input filter is often beneficial depending upon the characteristics of the communications receiver with which the "400" will be used. These input filters serve to reduce the bandwidth into the converter to the minimum required for a particular tone pair, thereby reducing unwanted noise and interference. Since various tone combinations are readily available, this option provides for mounting up to three plug-in filters within the cabinet. A concentric knob on the "Channel" selector allows these filters to be bypassed completely, or for any one of them to be switched into the circuit. In addition to the switching feature, a preamplifier is installed between the audio input and the filter to provide isolation, assure proper impedance matching, and compensate filter insertion loss.

OPTION #3 - Balanced 600 ohm input, transformer isolated

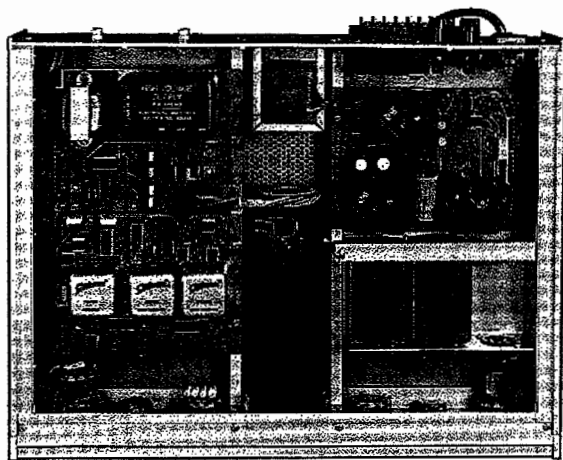


**ELECTROCOM MODEL 400
CONTAINING OPTIONS #1 and #2**

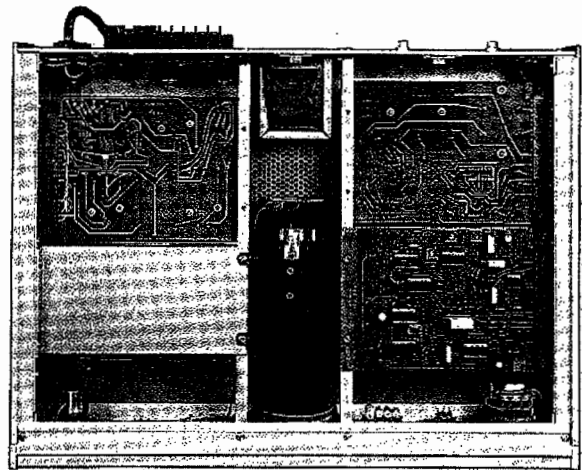
OPTION #4 - Polar current output providing DC current adjustable from ± 8 to ± 30 ma. into any loop resistance from 0 to 1000 ohms, and ± 8 to ± 20 ma. into a maximum of 2700 ohms. Current will remain constant regardless of power line variations.

OPTION #5 - Polar current output providing DC current adjustable from ± 8 to ± 40 ma. into any resistance from 0 to 1000 ohms, and ± 8 to ± 20 ma. into a maximum of 4000 ohms. Current will remain constant regardless of resistance or power line variations.

OPTION #6 - Maximum keying rate of 110 bauds for optimum performance with teleprinters using the ASCII code (100 wpm).

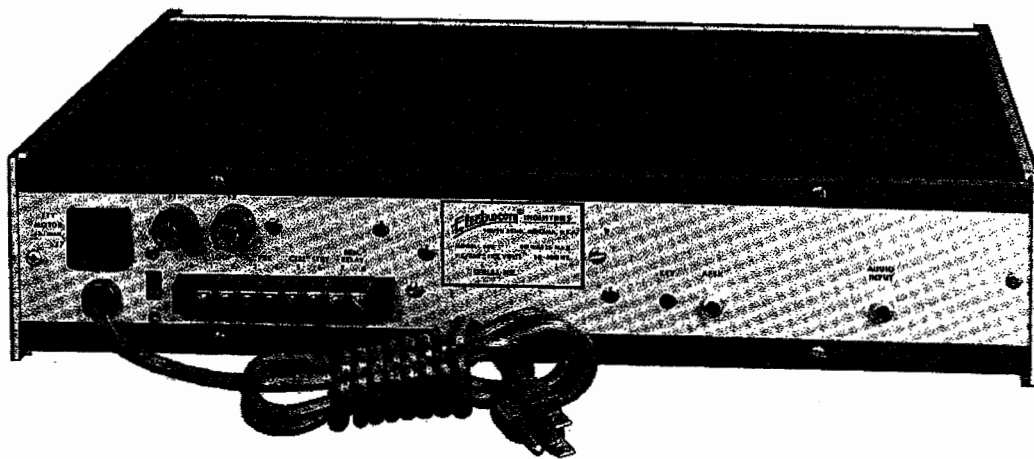


Top View



Bottom View

Internal views of ELECTROCOM® 400 (covers removed) including Option #2 containing two input filters. Notice that all test points and adjustments are easily accessible without card removal, thereby simplifying maintenance procedures. The plug-in cards are quickly removed should repair or replacement be necessary.



Rear view of Model 400 F. S. Converter. A break resistant barrier strip facilitates teleprinter and control interfacing without special connectors.

SPARE PARTS KITS:

1. Part Number 400060 - Semiconductors, CR Tube, and Fuses
2. Part Number 400040 - Electrolytic Capacitors

Electrocom® INDUSTRIES

1105 NORTH IRONWOOD DRIVE, SOUTH BEND, INDIANA 46615, U.S.A.

PRINTED IN U.S.A.

WARRANTY

Electrocom Industries warrants each new radio product manufactured by it to be free from defective material and workmanship and agrees to correct any such defect without charge, which under normal installation, use and service discloses such defect provided the unit is returned to Electrocom Industries at its factory, intact, for examination, with all transportation charges prepaid within one year from the date of sale to the original purchaser and provided that such examination discloses in our judgment that it is thus defective.

This warranty does not extend to any of our radio products which have been subjected to misuse, neglect, accident, incorrect wiring not our own, improper installation, or to use in violation of instructions furnished by us, nor extend to units which have been repaired or altered outside of our factory, nor to cases where the serial number thereof has been removed or changed, nor to accessories used therewith not of our own manufacture.

This warranty is in lieu of all other warranties expressed or implied and the above shall constitute the Buyer's sole right to remedy. In no event shall Electrocom Industries assume any liability for damage, loss, or expense directly or indirectly arising from the use of its products, or any inability to use them either separately or in combination with other equipment.

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