MODEL H-402CU

AUTOMATIC ANTENNA COUPLER

INSTRUCTION MANUAL

- INSTALLATION
- OPERATION
- MAINTENANCE

SERIAL NO. AFTER 151100

HULL ELECTRONICS COMPANY

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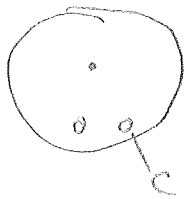
Pin C +12V



I. GENERAL INFORMATION

DESCRIPTION

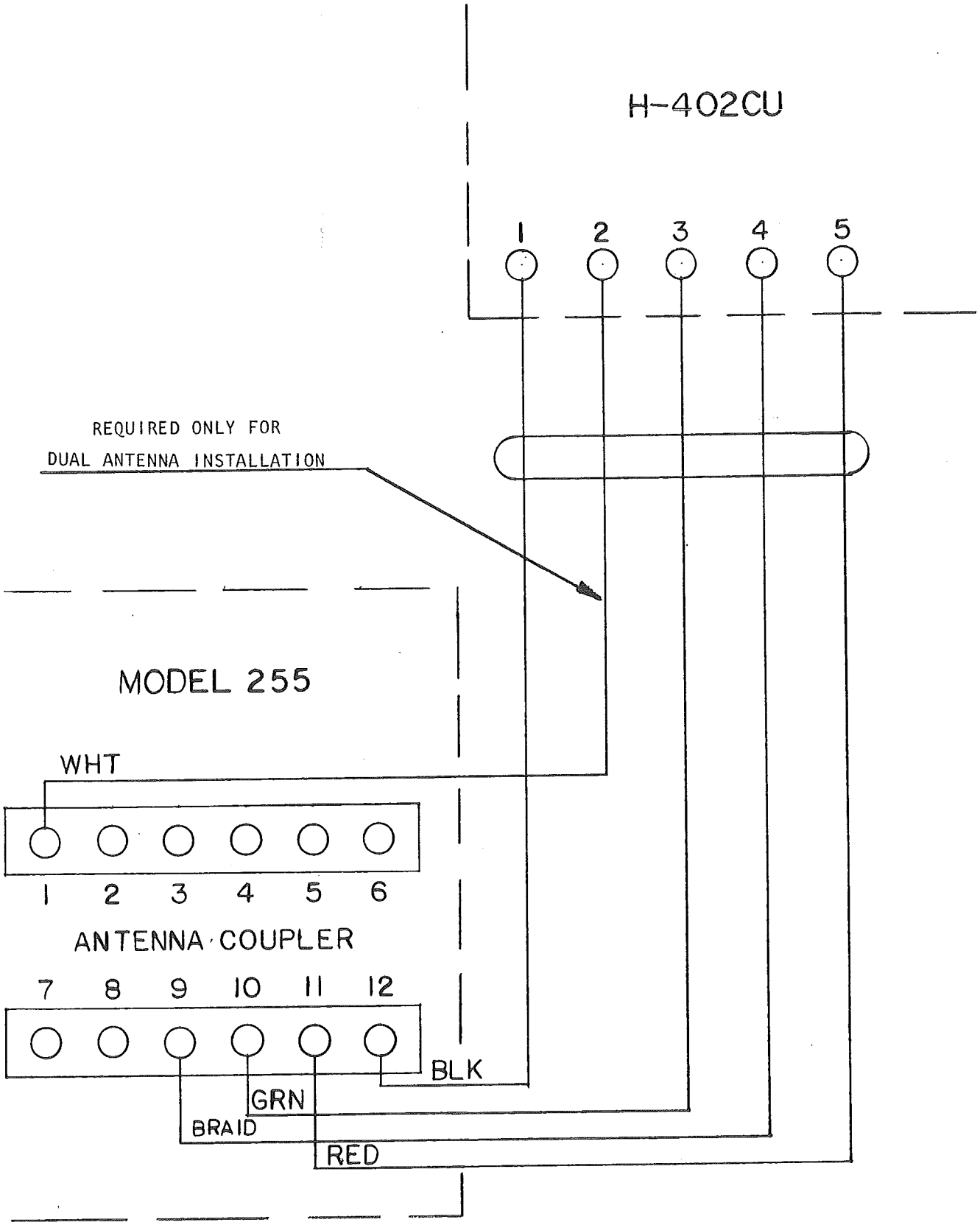
The Hull Model H-402CU Antenna Coupler is intended primarily for use with the Hull Model 255 and Model 922 SSB Radiotelephone. The coupler may be used, within its power rating, with any SSB Radiotelephone in the range 1.6-30 MHz. Although designed for marine service, the coupler is suitable for mobile and fixed-base applications. Its purpose is to match the varying impedance of typical marine whip antennas to the 50 OHM resistive impedance required by the radiotelephone. Tuning to the exact frequency selected is automatic and takes place immediately after a new channel is selected. In addition, the coupler adjusts the tuning if the antenna impedance changes during a transmission as a result of moving objects, etc. The coupler is a complete single-package unit intended for either interior or exterior mounting. The package is weather-proof, but should not be considered waterproof. All necessary power for operating the coupler is obtained from the companion radiotelephone.

EQUIPMENT FURNISHED

1. Hull Model H-402CU Antenna Coupler
2. Instruction manual

SPECIFICATIONS

Number of channels -	unlimited
Frequency range -	1.6-30 MHz
Power rating -	250 watts PEP max
SWR -	Less than 1.25 to 1
Tune power -	6 - 10 watts
Antennas -	any length from 8' to 150'
Mechanical -	Dimensions: 16½"H x 11⅜"W x 5½"D Weight: 9½ lb.
Options -	Coupler may be supplied to automatically switch between two antennas as desired.



CABLE CONNECTIONS

Hull Model 255 To H-402CU Coupler

II. INSTALLATION

GENERAL

Installation of the Model H-402CU coupler consists of installing the unit into the chosen location and connecting the coupler to the radiotelephone and the antenna. Interconnections and information on suitable antenna systems are given in this section. Technical data required for mating the coupler to any SSB radiotelephone are presented at the end of this section.

INSTALLATION

The coupler should be located close to the antenna base and as near as possible to the ground system. Mounting may be either vertical or horizontal. (See the note at the end of this section.) If the unit is mounted in a location exposed to the weather, a small (3/16" dia.) weep hole should be drilled in the cabinet at the lowest point. This allows water that collects as a result of condensation to drain from the cabinet.

Connection to the ground system must be short and direct. Use 2-inch wide copper strap, if possible. Otherwise, use several parallel runs of heavy wire. A discussion of suitable ground systems is given later in this section.

If the antenna lead-in is passed through a bulkhead, use a good quality glass feed-through insulator. The lead-in wire must be well insulated, such as GTO, since voltages at this point are quite high.

Connections to the radiotelephone are made via a 5-conductor cable and a suitable length of RG-8/U coaxial cable with a UHF male connector at each end. The length of both cables is not critical, and can be made as long as convenient.

Color coding of the 5-conductor cable is as follows:

NUMBER	COLOR	FUNCTION
1	BLACK	START
*2	WHITE	2 MHz
3	GREEN	KEY
4	SHIELD	GROUND
5	RED	+12V

*Connect only when two antennas are installed. See below.

The control cable and coaxial cables are routed through the stuffing glands at the cabinet bottom and connections are then made to the terminals at the bottom of the chassis. The ground strap connects to the bolt at the cabinet bottom and the lead-in wire from the antenna connects to the large insulated terminal at the cabinet top.

ANTENNA

As specified, the antenna may be any length up to 150 feet. The antenna may be mounted as convenient, except that locations near surrounding metal objects such as rigging, stacks or outriggers, other antennas, etc., should be avoided.

As an option, the coupler may be supplied for use with two antenna systems. Typically, a long-wire antenna would be used with 2 MHz channels and a vertical whip with the higher-frequency channels. With this option, the coupler is provided with two feed-thru antenna terminals and a built-in transfer relay. A cable lead is necessary back to the radiotelephone to actuate the relay when desired. The terminal at the coupler for this purpose is labelled "2 MHz."

GROUND SYSTEM

If the vessel is of metal construction, run the grounding strap to the nearest metal member. Connection must be electrically secure. Use a stainless bolt that has been brazed or silver-soldered to the metal member if possible. If the boat is of wood or fiberglass construction, proper grounding becomes more difficult. For the lower frequencies, 2 through 4 MHz, a copper strap to the engine block and other large metal objects will usually suffice. For the higher frequencies, a ground plane near the antenna base must be established. This can consist of large metal objects at deck level, copper screening, etc.

Quite often, an effective ground for the higher frequencies can be established by a resonant counterpoise for each band. The lengths required are:

6 MHz ..... 38'
8 MHz ..... 28'
12 MHz ..... 19'
16 MHz ..... 14'
22 MHz ..... 10½'

These counterpoises can consist of #16 wires, moderately well insulated, with one end of all the wires connected to the ground post of the coupler. The wires should be laid out horizontally under the deck in as straight a line as possible. The various wires can be bunched together. Make certain that the wire ends do not touch any metal objects.

DATA REQUIRED FROM RADIOTELEPHONE

The H-402CU Coupler requires from the radiotelephone:

TERMINAL	
+12V	Nominal 12VDC at 1.5 A max.
START	The DC level on the start line must be lower than +3.0 volts when a channel has been selected. Between channels, the level must rise to 6.5 volts or higher for a period of 200 milliseconds to signal the processor that a new tuning sequence will be required. When the level again drops below +3.0 volts the sequence starts. Line impedance is 10K to ground.
KEY	This line keys the transmitter on for low-level carrier tune up. The line is an open-collector NPN transistor capable of sinking 0.5 A max to ground. When the transistor conducts it must place a carrier of between 4 and 10 watts in the radiotelephone output.
2 MHz	When the dual-antenna option is installed, a nominal +12VDC on this line actuates the transfer relay to select a second antenna. Impedance of this line is 100K to ground.

Consult the factory for further information on mating the H-402CU with other equipment.

OPERATION

Operation of the H-402CU Coupler is fully automatic and a tuning sequence starts whenever a new channel is selected. In addition, if the antenna becomes detuned while the transmitter is in operation, the coupler will fine-tune as necessary to maintain an optimum match.

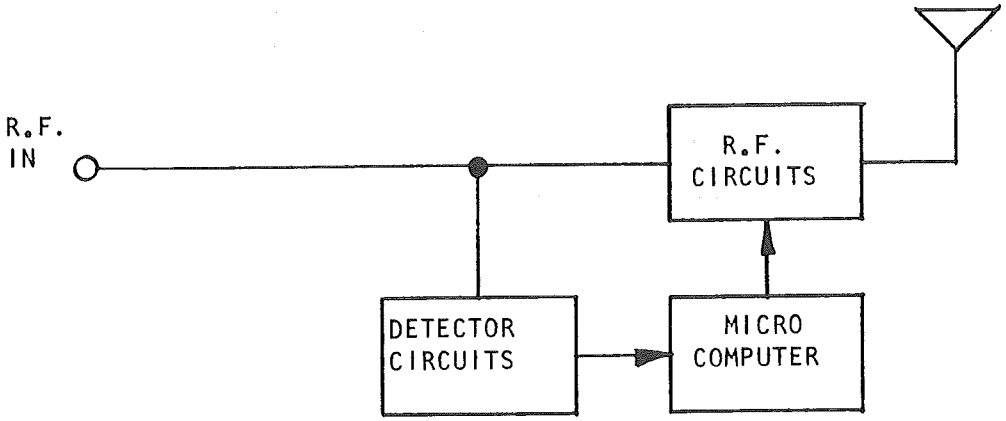
OPERATION WITH THE HULL MODEL 255

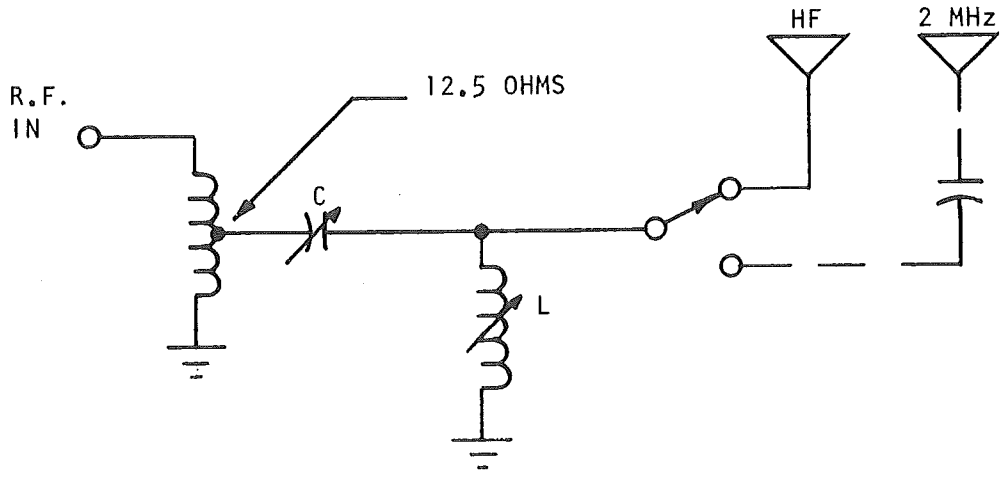
When a channel is selected at the Model 255 Radiotelephone, the coupler automatically begins a tune-up sequence. Typically, tune-up requires ½ to 2 seconds. During the tune-up period the yellow LOCK lamp on the front panel will stay out. When the lamp lights, the radiotelephone is ready for use.

During subsequent transmissions, the coupler may fine-tune as necessary to maintain the antenna in exact tune. This is not noticeable to the user and does not impair the transmission.

OPERATION WITH THE HULL MODEL 922

Operation of the H-402CU Coupler with the Model 922 is essentially the same as with the Model 255. Since frequency selection of the Model 922 is by a rotary switch, the coupler begins tuning whenever the switch position is changed. Also, the coupler tunes when the set is first turned on.





MODEL H-402CU
BASIC CIRCUITS

THEORY OF OPERATION

GENERAL

The Hull H-402CU Automatic Antenna Coupler consists of three function groups. These are: RF Circuits, Detector Circuits, and Microcomputer Control Circuits. A detailed description of each group is given below.

RF CIRCUITS

The basic RF Circuit of the coupler is shown on the opposite page. The incoming 50 OHM signal is transformed to 12.5 ohms by a broad-band balun. Variable capacity and inductance values are then adjusted to provide a match between the antenna and the 12.5 ohm value. As an option, a second antenna may be connected for use at the lower frequencies. Should this second antenna exceed a given length, it may be shortened electrically by series capacitors which are provided as a part of the option.

The capacity and inductance required in the "L" matching network consist of strings of discrete capacitors and inductors. The values of C and L are varied by switching the capacitors and inductors in and out of the circuit as required. This switching is done with relays controlled by the microcomputer.

DETECTOR CIRCUITS

There are four detector circuits which sense the condition of the RF power flowing into the "L" network described above. They are: phase detector, R detector, SWR detector, and power detector.

PHASE DETECTOR

The phase detector senses the relative phase between the voltage and current flowing into the RF circuit. Referring to the schematic diagram, the RF current is sensed by L15, output from which causes conduction through CR1 and CR2 on positive-going peaks. C1 and L14 form a 90° phase-shifter circuit which senses the voltage on the RF line. Into a resistive load, the current peak occurs simultaneously with a voltage null from C1 and L14. This causes equal conduction through CR1 and CR2 and the net output voltage from the detector is zero. If the RF load is not pure resistive, output from the detector will be positive or negative due to the voltage from C1 and L14 arriving out of phase as compared to the output from L15.

R DETECTOR

When the RF load is purely resistive, the R detector determines if the resistance is above or below 50 ohms by comparing the ratio of voltage and current flowing into the RF circuit. L16 senses the current and causes CR3 and CR4 to conduct during current peaks. C13 and C14 divide the RF voltage to a suitable level and output from this divider is applied to both diodes equally. When the load is exactly 50 ohms, the current signal from L16 is twice the voltage from the divider and output from the detector will be zero. If the impedance on the line varies either above or below the 50 ohm value, output from the detector will be a positive or negative DC value. Note that the R detector output is valid only when the load is purely resistive.

SWR DETECTOR

The SWR detector delivers zero output when a pure 50 ohm condition exists on the line. If the line condition varies from 50 ohms either in resistance or reactance, the detector produces a positive going DC output.

L17 provides a current pickup while C18 and C19 deliver a divided sample of the voltage on the line. As long as the two inputs to CR5 are equal in amplitude and phase (50 ohm resistive condition) there is no diode conduction and detector output is zero. An unbalance in either amplitude or phase, however, will cause the diode to conduct and a positive DC output will appear.

SWR DETECTOR Continued

The positive detector output is compared with a fixed DC level to determine if the SWR condition on the line is above or below a set limit. The fixed DC is shifted higher during normal transmissions as compared to the level used during the low-power tune up sequence. Thus, the SWR detection process becomes largely immune to differences in power level.

POWER DETECTOR

A voltage divider, R12 and R19, delivers a low-level voltage output whenever RF power is present on the line. This voltage is rectified by CR6 and compared with a fixed level set by R18 and R22 to determine when RF energy is present.

MICROCOMPUTER CONTROL CIRCUITS

The microcomputer consists of U9, U10 and U11. Inputs to the computer are the four detector outputs described above. The computer outputs control 21 relays that, in turn, set the necessary values for the RF matching network. The computer is also connected to the transmitter through the START and KEY lines which control the tuning sequence to be described.

Normally the computer is held in the standby mode by flip-flop U12, but either of two conditions can "wake up" the system. If a signal is present on the START line from the transmitter, indicating that the channel has been changed, the computer will wake up and begin a full tune-up sequence. In this mode the transmitter is keyed on by the computer and a low-level carrier is provided to supply tune-up energy.

The second condition that will wake up the computer is when the power detector indicates that RF energy is present, as during a normal transmission. In this mode, the computer wakes up, examines the SWR condition, and directs small adjustments to the tuning, if required, to hold SWR to a minimum. This operating condition is termed the "Tracking" mode. If desired, the TRACK mode can be omitted by jumping two posts on the circuit board. If the antenna conditions are not prone to sudden change, it is unnecessary to use the TRACK mode and it should be disabled.

During the tuning and tracking sequences, the computer makes a series of instructions to the relays. Each time the relay data is changed, the new information is latched into U4, U6, and U8. These latches, in turn, are connected to the relay drivers U3, U5, and U7. After the new relay data is set, the computer waits about ten ms and then samples the detector outputs. If a proper match has been achieved, the computer turns the MATCH FOUND lamp on and shuts itself off by toggling flip-flop U12. Otherwise the sequence continues.

Under some grounding conditions, attempting to match the antenna at its exact resonant frequency is not possible. For this reason, a series capacitor in the antenna input lead, normally shorted by relay K13, is inserted into the circuit if the system has not found a match on the first pass through the routine.

As a means of extending the operating frequency range of the coupler, C110 in the grounded end of the inductance string can be inserted into the circuit by actuating relay K23. The software is arranged so this occurs on the third and fourth passes through the tuning routine and provides correct tuning at frequencies higher than 24 MHz.

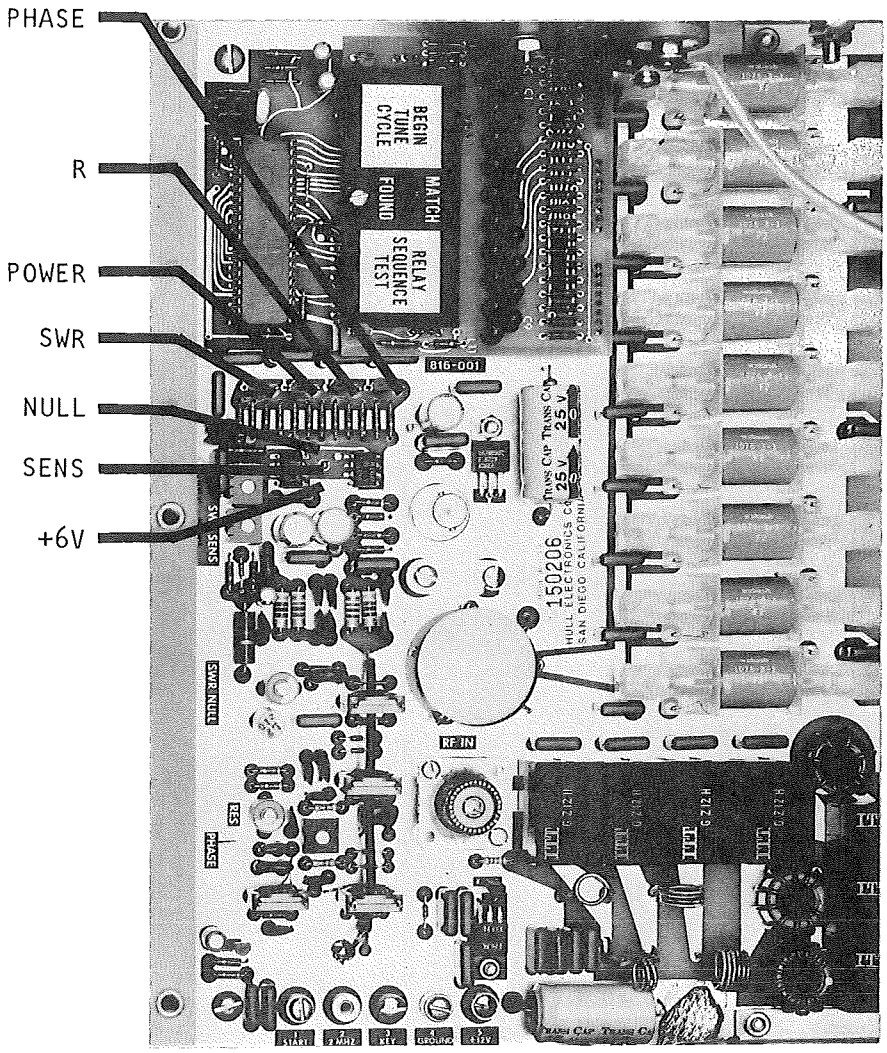
During the initial tune-up sequence, the computer will "time out" in about ten seconds if no match has been found. In this case, the computer shuts itself off without lighting the MATCH FOUND lamp.

TEST PANEL

A test and status panel is provided to permit local operation and testing of the coupler and to observe the data delivered to the various relays.

If the RELAY SEQUENCE TEST button is pressed, a test program is initiated that energizes each relay in turn. If each relay status lamp lights in turn and each relay is heard to operate, the entire computer circuitry, the latches, the relay drivers, and the relays are proven to be operating correctly. The sequence may be stopped at any relay by pressing the RELAY SEQUENCE TEST button a second time. Pressing the button a third time will complete the sequence.

Pressing the BEGIN TUNE CYCLE pushbutton causes the coupler to perform a complete tune-up sequence, provided a valid channel has been selected at the transmitter.



MODEL HC-402CU
TEST POINTS

ALIGNMENT

GENERAL

The H-402CU Coupler has been thoroughly tested and aligned at the factory and re-alignment in the field should not be attempted unless good quality test equipment is available and all other possible causes of malfunctioning have been investigated.

EQUIPMENT REQUIRED

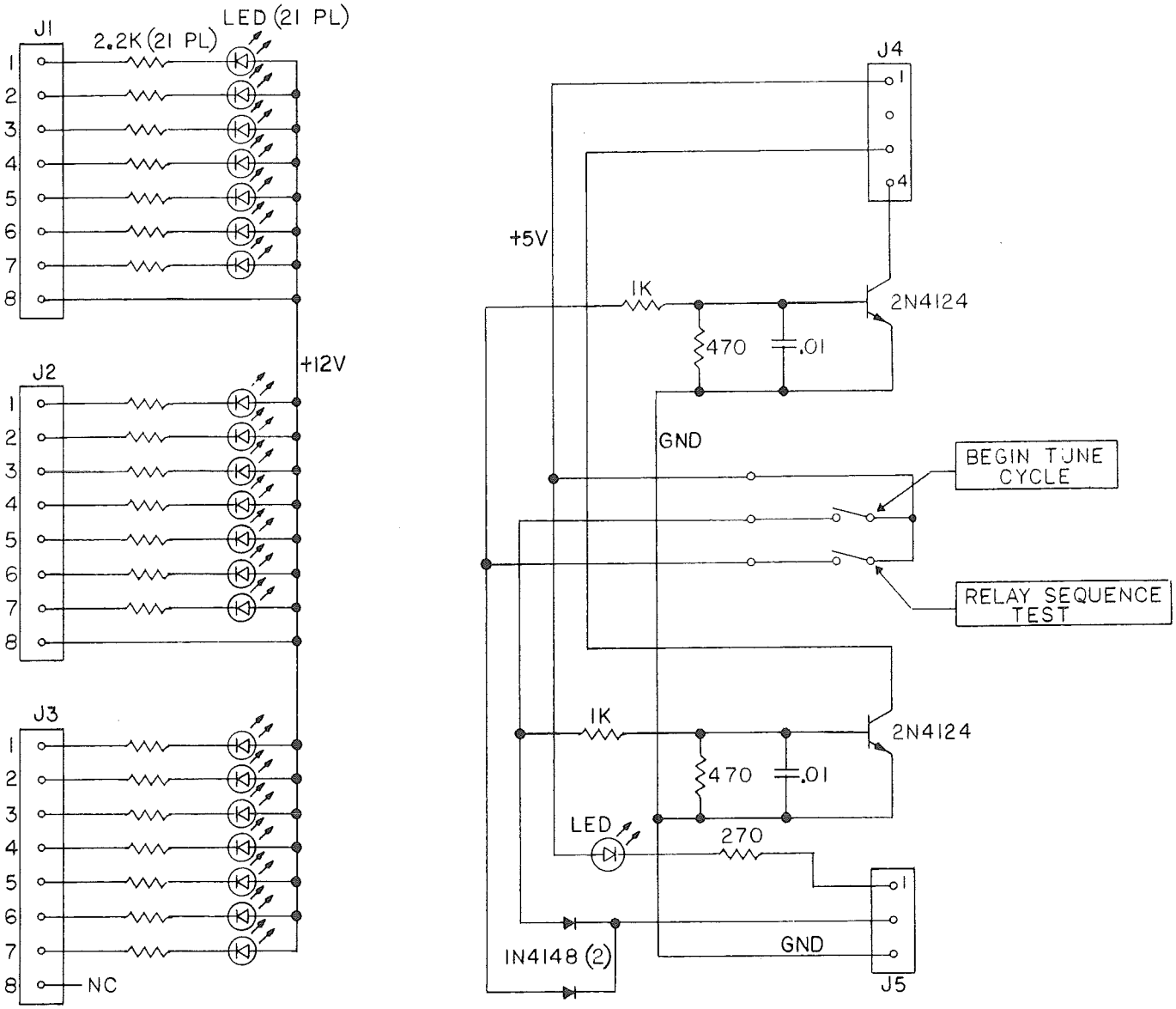
50 OHM Dummy Load with Connecting Cable

Oscilloscope

High Impedance DC Voltmeter

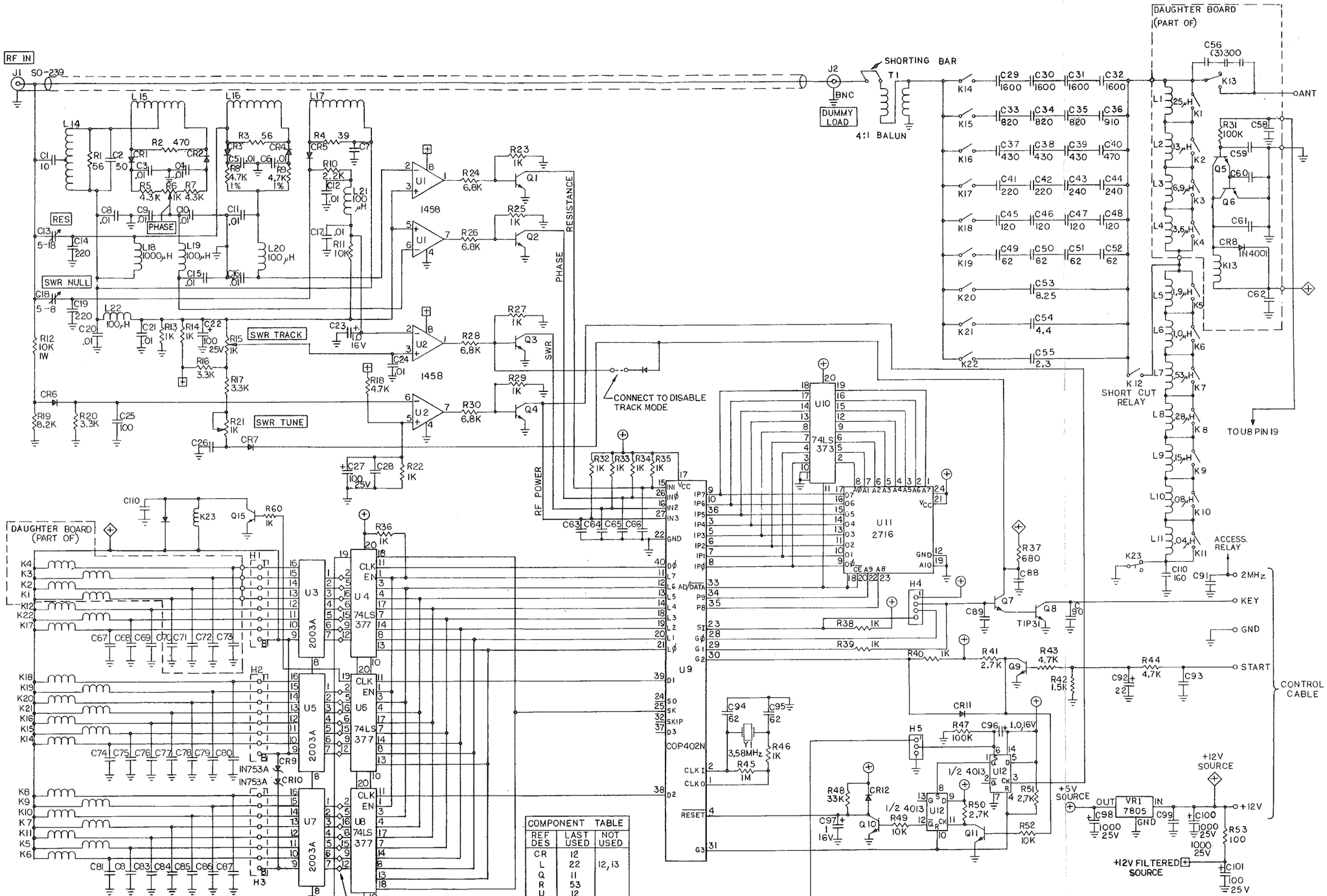
ALIGNMENT PROCEDURE

1. Connect the coupler to either a Model 922 or Model 255 Radiotelephone. Disconnect the jumper strap located adjacent to the BNC connector on the coupler. Connect the dummy load to the BNC connector. Select a 6 MHz channel on the Model 922 or Channel 172 on the Model 255.
2. Wait for the coupler to time out (about 10 seconds). During the following procedures, the coupler may hunt. This is normal and should be ignored.
3. Connect the scope to the PHASE test point (see drawing on the opposite page). Push the TEST button on the Model 922 (PUSH TO TEST button on the Model 255). Adjust the PHASE pot until the scope baseline is alternating between zero and +5 volts with about equal time in each position. This adjustment assures that the phase-amplifier output is swinging from zero to +5 volts output when RF energy is present.
4. Connect the scope to the R test point. Push the TEST button on the Model 922 (PUSH TO TEST button on the Model 255). Adjust the RES trimmer until the scope baseline is alternating between zero and +5 volts with about equal time in each position.
5. Connect the scope ground to the "+6V" test point and the scope probe to the NULL test point. Push the TEST button on the transmitter and adjust the SWR NULL trimmer for zero voltage level as shown on the scope. NOTE: This adjustment may also be made with a high-impedance voltmeter.
6. Turn the Model 922 channel selector to the position between channel 1 and 11 (Press CLR button on the Model 255). Connect the scope ground (or the negative lead of a Hi-Z voltmeter) to the "+6V" test point. Connect the scope probe (or voltmeter positive lead) to the SENS test point. Adjust the TRACK trimmer for an indication of +1.0V. Next, disconnect the RF coax lead-in from the coupler "RF IN" jack and select any channel on the radio-telephone. While the 10 second time-out period is occurring, adjust the TUNE trimmer for a reading of +0.2V. NOTE: The TRACK and TUNE adjustments must **both** be performed in the order given whenever either is readjusted.



H-402CU TEST PANEL

H-402CU TEST PANEL



COMPONENT TABLE		
REF DES	LAST USED	NOT USED
CR	12	
L	22	12, 13
Q	11	
R	53	
U	12	
C	101	

5. C53-C55 ARE ETCHED ON P.C. BOARD.
4. TRANSISTORS ARE 2N4124.
3. RESISTORS ARE 1/4 W VALUE IN OHMS.
2. DIODES ARE IN4148.
1. CAPACITORS ARE .1µ VALUE IN MICROFARADS.

NOTES: (UNLESS OTHERWISE SPECIFIED)

AUTOMATIC ANTENNA COUPLER

WARRANTY

THIS PRODUCT WAS SHIPPED WITH OUR LIMITED WARRANTY CERTIFICATE AND LIMITED WARRANTY REGISTRATION CARD. BE SURE THAT THE REGISTRATION CARD IS COMPLETED AND MAILED.

HULL ELECTRONICS COMPANY RESERVES THE RIGHT TO MAKE PERIODIC PRODUCT IMPROVEMENTS OR MODIFICATIONS TO ITS PRODUCTS WITHOUT BEING OBLIGATED TO RETROFIT OR MODIFY ANY PRODUCT WHICH HAS ALREADY BEEN SHIPPED.

Hull Electronics Company
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