Phase II Transmission System Manual
for the

TR-20 TRANSMITTER
&
CP-15 COUPLER

RADIO SYSTEMS INC.
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1. TRANSMITTER OPERATION AND MAINTENANCE

Once correctly installed and set up, the transmitter and coupler units will function completely automatically. It is not necessary to turn the system off while not in use. However, for long off-air periods, it is recommended that the units be disconnected from building power supplies.

Because these units are normally operated at remote locations, frequent inspection is strongly recommended. Weekly checks should be made for proper audio level and transmitter output matching. Tests should also include a visual inspection of all components and listening evaluation of the audio quality.

System performance will depend on:

A. Coupler Location - Evaluate several coupler-to-building wiring connection points until you find one that provides full area coverage and low background noise. The main basement fuse panel is not necessarily the optimum coupling location.

B. Coupling Connection Method - Signal transfer can usually be accomplished via several connection alternatives. A few of the most common are illustrated on the following page. Any available wiring systems, including intercom wiring and conduit systems, may be utilized and should be tested. Also, check to insure that you are not interfacing with other building systems. Note that if you are connecting the coupler neutral screw to a ground, try different grounding points including water pipes and case grounds.

C. System Design - It is critical to know the layout and scope of your existing antenna system. In large buildings, multiple electrical systems may necessitate several coupler points for complete coverage. Conversely, multiple buildings may be served from a single coupling point if the AC systems are common. Consult all available plans before starting test work.

2. TR-20 INSTALLATION AND OPERATING INSTRUCTIONS

Transmitter performance and audio quality are highly dependent on proper system design and pre-installation tests. Application notes outlining these procedures are available from Radio Systems.

Follow these steps for installation and operation:

1) Connect AC, Audio and RF cables as described on the installation and interconnection sheet.

2) Turn audio level and power adjust controls to minimum (fully ccw).

3) Properly load the transmitter. If a CP-15 coupler is being used, this may be accomplished by setting the coupler in the "match" position.

4) Turn on power switch. The LED will light.

5) Set audio level. Note: your TR-20 transmitter contains an automatic level control circuit. Follow these set-up procedures for automatic or manual operation:

Automatic Audio Level Control

A) Set the limiter key in the horizontal (limiter in) position.

B) Provide the transmitter with audio at standard studio levels

C) Set audio level control for occasional to frequent peak indicator flash. Each flash indicates 100% modulation and limiter activation. The higher the flash rate, the greater the limiting and higher the overall audio level. Use a high quality portable radio to determine the amount of limiting desired.

Manual Audio Level Operation

A) Set the limiter key in the vertical (limiter out) position.

B) Provide the transmitter with audio at standard studio levels.

C) Set audio level control for occasional peak indicator flash only.

6 Turn the power adjust control to maximum (fully cw).

3. CP-15 INSTALLATION AND OPERATING INSTRUCTIONS

Coupler performance and radio reception are highly dependent on proper system design and pre-installation tests. Application notes outlining these procedures are available from Radio Systems.

1) Connect RF and AC cables as described on the installation and interconnection sheet.

2) Turn on building circuit breakers

3) S-1 in match position

4) S-2 in forward position. Meter should indicate full scale.

5) S-2 in reflect position.

6) Set S3, S4, S5 and S6 for minimum meter reading. A patient, systematic approach must be taken to test all possible combinations of impedance compensation and capacitance cancellation setting to achieve the lowest meter reading.

7) Determine SWR

   A) Set S-2 in forward

   B) Adjust R-8 for full scale (300)

   C) Set S-2 in reflect, note reading and calculate

   $$\frac{300 + \text{reading}}{300 - \text{reading}} = \text{SWR}$$

   For example, if the reflected reading is 100

   $$\frac{300 + 100 = 400}{300 - 100 = 200} = 2 \quad \text{SWR is 2:1}$$

   A reading higher than 2:1 (or 100 when reading reflected power) should be treated with suspect and the matching redone.

8) Set S-1 in operate

9) Reduce transmitter RF power to the minimum necessary for desired area coverage.

4. CARRIER CURRENT BROADCASTING

Carrier current refers to the use of an existing network of conductors, usually a building's AC electrical system, as a broadcast antenna for non-licensed, limited area, broadcasting.

The CP-15 coupler is specifically designed to compensate for the inefficiencies of these makeshift antennas, and provide an acceptable transmitter to antenna match. Specifically, the coupler functions to:

1) Isolate the transmitter from building high voltage through the use of high pass capacitors and fuses.

2) Compensate for antenna impedance mismatch through the use of multi-tap torroidal transformers.

3) Compensate for antenna stray reactance through the use of a decade system of capacitor combinations.

An internal VSWR metering system indicates when the proper combination of corrective settings has been selected for optimum signal transfer.

Because of the many variables in building wiring systems, signal quality can vary radically and the following parameters should be carefully tested prior to system final installation. These tests can only be made by temporarily installing a transmitter and coupler, adjusting for proper antenna match, applying audio signal and evaluating signal quality on various radios through the intended coverage area.

5. CABLE SYSTEMS AND BROAD AREA COVERAGE

Where wiring does not exist, it is possible to install various cable specifically for the purpose of radiating broadcast signal to a restricted area.

Option #1 - "Leaky" cable systems

Several coaxial type cables are now being commercially manufactured to specifically "leak" or radiate energy relatively uniformly along their length. This is accomplished by either utilizing slots in the cable shield or a thinly braided shield to radiate signal. In a cable system, the end of the run is always terminated with a non-inductive load.

Cable can be installed underground along a roadway for motorist radio services or on the perimeter of a low rise building for room coverage. Radiation is governed by cable type and transmitter signal level, but is generally not greater than 100' along the cable length.

Option #2 - Using standard coaxial cable for radiating systems

By reversing the polarity of a feed to standard coaxial cable (that is feeding the hot side of the transmitter output to the shield of the coax and using the inner conductor for signal return) similar "leaky" cable results can be obtained. Properly terminating this system presents a correct load to the transmitter and causes the signal strength to be uniform along the feed. Experimentation with all cable systems is in order to determine performance perimeters and maximum usable cable lengths. Variables such as ground composition, soil moisture level and nearby metal and ground structures will all effect performance.

Option #3 - Single conductor cable for broad area coverage

A grid of single conductor cable can be installed underground to inexpensively cover a large field area. In this system, rather than terminate each line, a coupler is utilized to correct for impedance and reactance components.

Cable can be installed as pictured on the following page, in a balanced array where each alternating row is either transmitter hot or ground, thereby simulating a dipole antenna. Systems can also be designed when one continuous run of wire is looped around the field and connected to the coupler hot (screw #2) output. The ground side ()neutral screw) is then connected to a solid earth ground.

Once again, experimentation is suggested to achieve the optimum performance.

6. THEORY OF OPERATION - TRANSMITTER

6.1 POWER SUPPLY

The power transformer (TI) feeds a full wave bridge rectifier(D1 to D4) through a surge suppression filter (R1, R2, C1, C2). Under normal conditions, the DC voltage across the filter capacitor (C3) is 30 volts. Voltage for the low level circuits is supplied by a three terminal regulator (VR1) and a zener diode (D5). Two resistors (R3 and R4) set the regulator output voltage.

6.2 AUDIO

An audio transformer (T2) provides a balanced 600 ohm isolated input. One half of a dual OP amp (IC3A) amplifies the signal which is then routed to the modulator (IC2) or to the limiter when it is switched in circuit.

The limiter provides up to 20 dB of gain reduction to maintain the audio level within a predetermined range and prevent overmodulation. It consists of a full wave active rectifier (IC5), a limiting amp (IC4) and a control element (Q3). Factory sealed pots set the control bias (R17) and output level (R45).

The other half of the dual input OP amp (IC3) turns on the peak flasher LED (D7) at about 100% modulation. This point is set by R11 and R12.

6.3 OSCILLATOR

The carrier signal is generated by a stable crystal oscillator utilizing one section of IC6. The output of this oscillator is divided by a factor of 2 or 4 (depending on the desired output frequency) by IC1. This signal is then fed to the remaining three sections of IC6 which function as a buffer and yield a 10 vPP square wave at the carrier frequency.

6.4 MODULATOR/AMPLIFIER

Modulation is accomplished by IC2 which is configured to function as a high-quality AM modulator. The carrier signal is fed through the power level controls R25 and R26 to IC2 and the audio signal is coupled to IC2 through C20. The output of IC2 is a low level AM signal which is directly coupled to Q1 which functions as a buffering emitter follower. A Class A broadband power amplifier built around Q2 provides drive for the main final power amplifier.

6.5 POWER AMP/FILTER

Two balanced emitter transistors (Q103 and Q104) are push-pull coupled as a linear amplifier. A darlington transistor ((Q102) adjusts the DC bias of the output transistor pair (Q103 and Q104). The output amp is fuse protected (F101) for severe SWR or overdrive conditions.

Coils (L101 and L102) and mica-capacitors (C106 through C110) are used to provide a sharp cut-off filter for harmonic rejection. Three different sets of components are used to make up this filter depending on whether the transmitter frequency is within the low (530 - 830 kHz), mid (830 - 1230 kHz) or high (1230 - 1610 kHz) portion of the band.

6.6 DETECTOR

A detector circuit supplies a high impdeance audio signal to a 1/4 inch jack as a convenient test point and monitor output.

6.7 COUPLER

The CP-15 coupler is a matching device with impedance compensation and reactance cancellation capability, along with a high pass filter for carrier current operation.

A cascaded impedance correction system uses two high permeability ferrite coils (T2 and T3) to provide three and five impedance taps for a total of 15 ranges which are selected through two switches (S5 and S6). Exact reactance cancellation is accomplished by selecting combinations of high voltage mica-capacitors (C3 through C10) which are switched in series with the RF output by two decade-type switches (S3 and S4). Finally, capacitors (C11, C12 and C13) block the 60 cycle energy from entering the coupler and fuses (F1, F2 and F3) protect the line in case of capacitor failure and provide a convenient way of eliminating a phase.

The "match-Operate" switch (S1) activates the bridge circuitry and, through a transformer (T1) which lowers the bridge driving impedance, dummy loads 90% of the RF input power for protection during set-up. The "Forward-reverse" switch (S2) enables the DC milli-ammeter to look at reflected or forward power through the bridge so that SWR can be optimized by selecting the proper cancellation components. The calibration pot (R8) enables calculation of actual SWR by setting a forward power reading reference point.

7. TROUBLE-SHOOTING GUIDE

7.1 AUDIO PROBLEMS

A. No audio

Check for a signal on the audio line from the studio with headphones or a meter.

Adjust the transmitter audio level control setting.

Note that the audio limiter key is inserted.

B. Audio Distortion

Ensure that a clean, undistorted signal is being fed from the studio.

Check that the transmitter audio level control is set properly (occasional to frequency LED flash).

C. Hum

Ensure that clean, hum-free audio is being fed to the transmitter.

Evaluate the coupling procedure and location (detailed information on carrier noise and coupling techniques is available from Radio Systems).

D. Garble

Ensure that no other station transmitter on the same frequency can be received in this location.

E. Static

This indicates low signal strength. Consult "RF Problems".

7.2 RF PROBLEMS

A. No Signal

Check fuse F-101 on transmitter amplifier board.

Check coupler fuses.

Ensure that building circuit breakers for coupler power are on.

Inspect transmitter to coupler coaxial cable.

B. Low signal Strength

Ensure that coupler switch is in "operate" position.

Raise transmitter power control setting.

Rematch coupler to optimize SWR.

Survey other building coupler locations (extensive information on coupling techniques is available from Radio Systems).

C. Poor Matching

Check that neutral and hot wires have been properly connected to coupler.

Try other coupling techniques and locations.

D. Whistle (heterodyne)

Check if other stations are broadcasting on or closed (within 5 kc) to your operating frequency.

Check if any other of your transmitters can be received in this building (if so- you should raise or lower the frequency of one transmitter by 10 kc).

8. SPECIFICATIONS

TR-20 Transmitter

Type of Emission	Amplitude Modulation (A3)
Frequency Range	500 kHz to 1.7 MHz
Frequency Stability	+/- 002% (0° to 35° C)
Carrier Shift	2% maximum
Harmonic Attenuation	45 dB or better
Noise	60 dB below 100% modulation
Audio Input	600 ohms balanced
(for 100% modulation)	30 dBm minimum
Frequency Response	20 Hz to 15 kHz +/- 1.0 dB maximum
Audio Distortion	Less than 2% @ 99% modulation
Modulation Monitoring	100% peak flasher
	Built-in envelope detector
Modulation Limiting	Built-in 100% peak modulation limiter
	20 dB gain reduction; defeatable
Power Consumption	230 watts at 115 VAC maximum
Size	Width 15', Height 9", Depth 6"
Weight	14 lbs.

CP-15 Coupler

Power Input	20 watts RMS maximum
Input Impedance	50 ohms unbalanced
Output Impedance	1 to 50 ohms in 15 ranges with built-in capacitance decades
Matching Circuit	Two staged, multifilar wound ferrite transformers
Metering	VSWR bridge, forward and reflected readings
AC Line Connection	500V maximum, line to line and ground
Size	Width - 9", Height - 9", Depth - 3"
Weight	5 1/2 lbs.

9. WARRANTY

Radio Systems, Inc., warrants this equipment to be free from defects in materials and workmanship for a period of one (1) year.

This warranty applies only to the Radio Systems, Inc., product provided and not to any other manufacturers equipment which may have been supplied in conjunction with this product.

This warranty extends to first users of the product and future owners who purchase the product within the warranty period.

The terms of this warranty are null and void if this product is stored or operated in an environment not conducive to electronic equipment, or shows signs of misuse or modifications which affect the proper functioning of the product. This warranty does not apply to damage caused by fire, smoke, flood, lightning, or acts of nature and physical abuse.

Radio Systems, Inc., and its associated companies, authorized distributors, and personnel are not liable for loss of revenues or other damage, or effects to the broadcast signal quality or coverage which may result from the improper functioning of this product.

10. REPAIR POLICY

Technical assistance is available at any time, at no charge, by phone or correspondence, directly from the factory. Written engineering updates and technical notes will be provided on an ongoing basis to those users who complete and return the warranty registration card (if supplied with the product purchased).

During the warranty period, shipment of small parts and assemblies will be made via next business day air service with no shipping charge to the user. Emergency shipments of replacement parts and circuits will be made at user's request. Parts and repair charges will be made COD or on Net-30 day terms to users with established accounts.

During the warranty period, full credit or return of COD charges will be made to users who return the defective parts or circuits within 30 days, if the damage is covered under the terms of the warranty.

After the warranty period users may return loaned replacement circuitry only for credit or return of COD charges within 30 days of receipt of repaired defective circuitry. Credit will be allowed if the replacement circuitry is returned in like-new condition.

10.1 RETURN INSTRUCTIONS

Contact the factory for a return authorization number.

Pack all items carefully and ship pre-paid, via UPS insured, to:

Radio Systems, Inc.

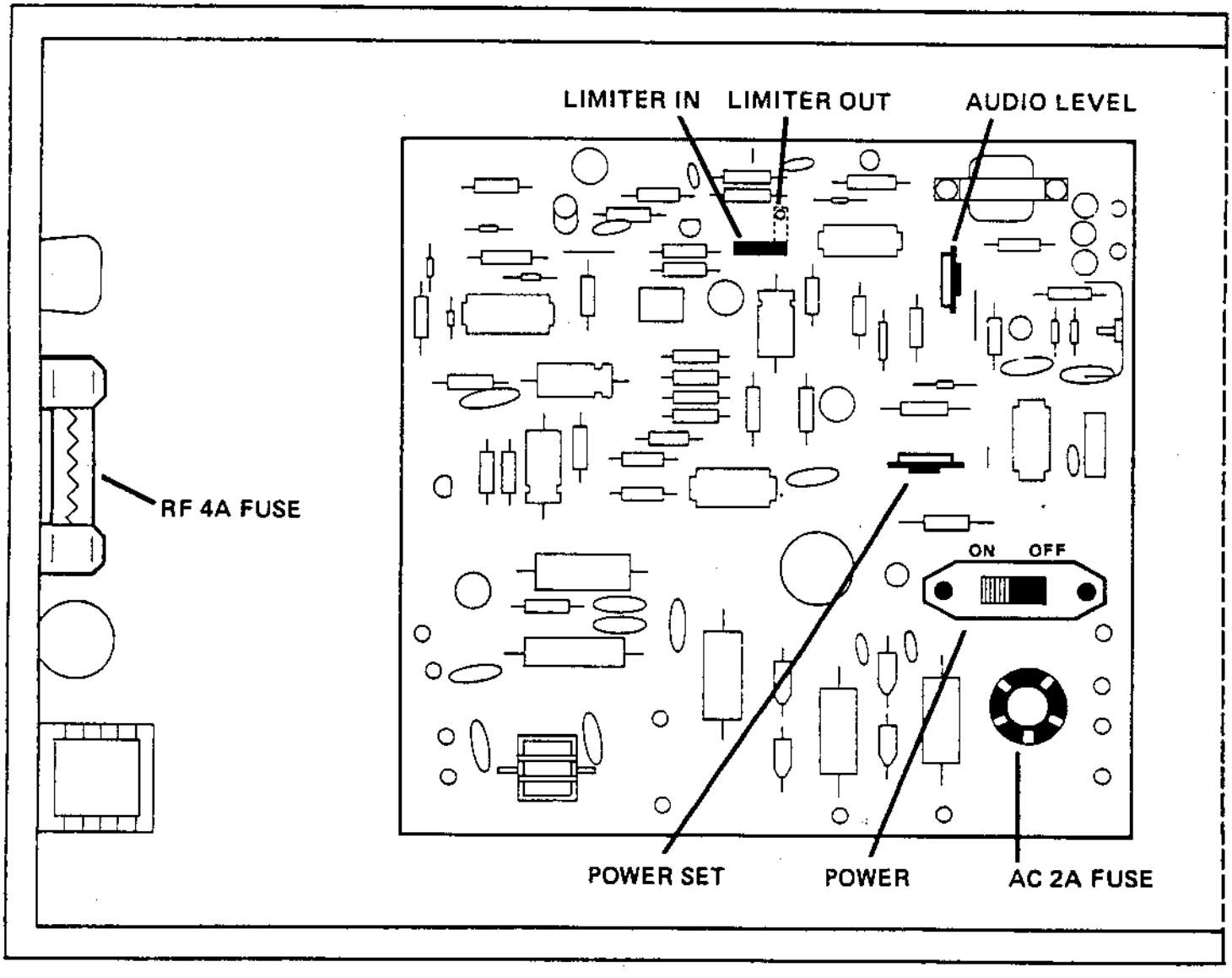
Attn: R.A. #_____

601 Heron Drive

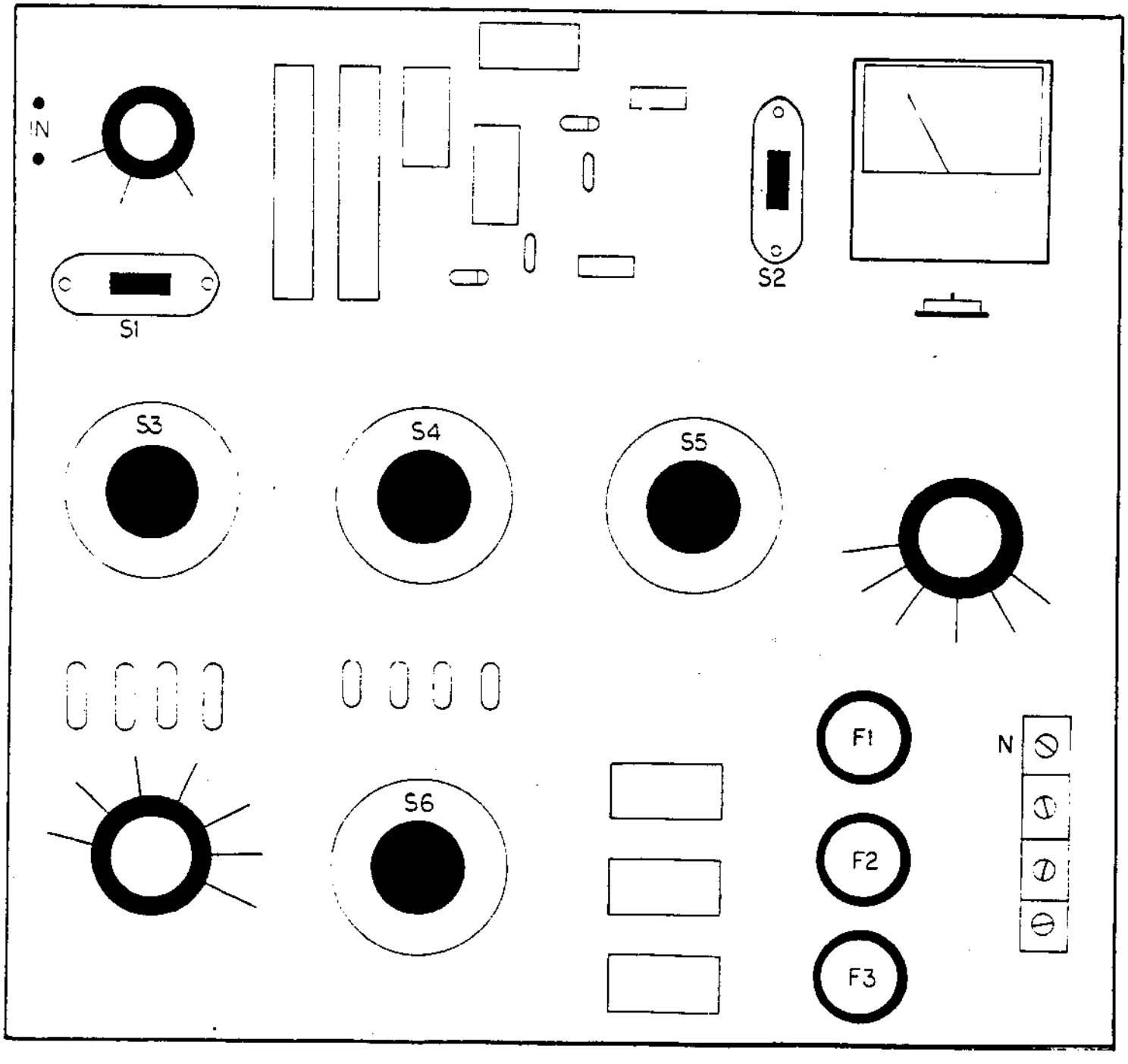
Bridgeport, NJ. 08014-0458

Enclose a note which includes your name, company, phone number, the serial number, return address (no box numbers), and a complete description of the problem.

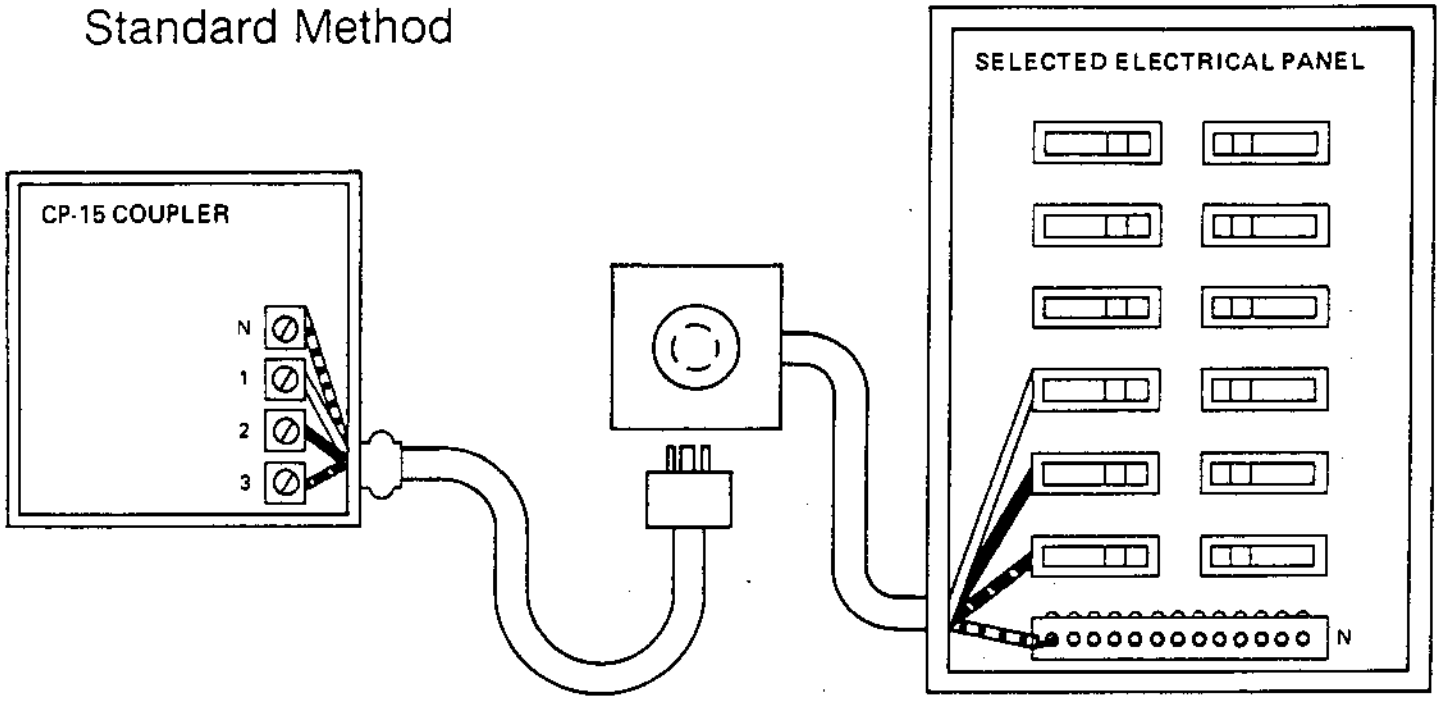
TR-20 TRANSMITTER CONTROL LOCATIONS



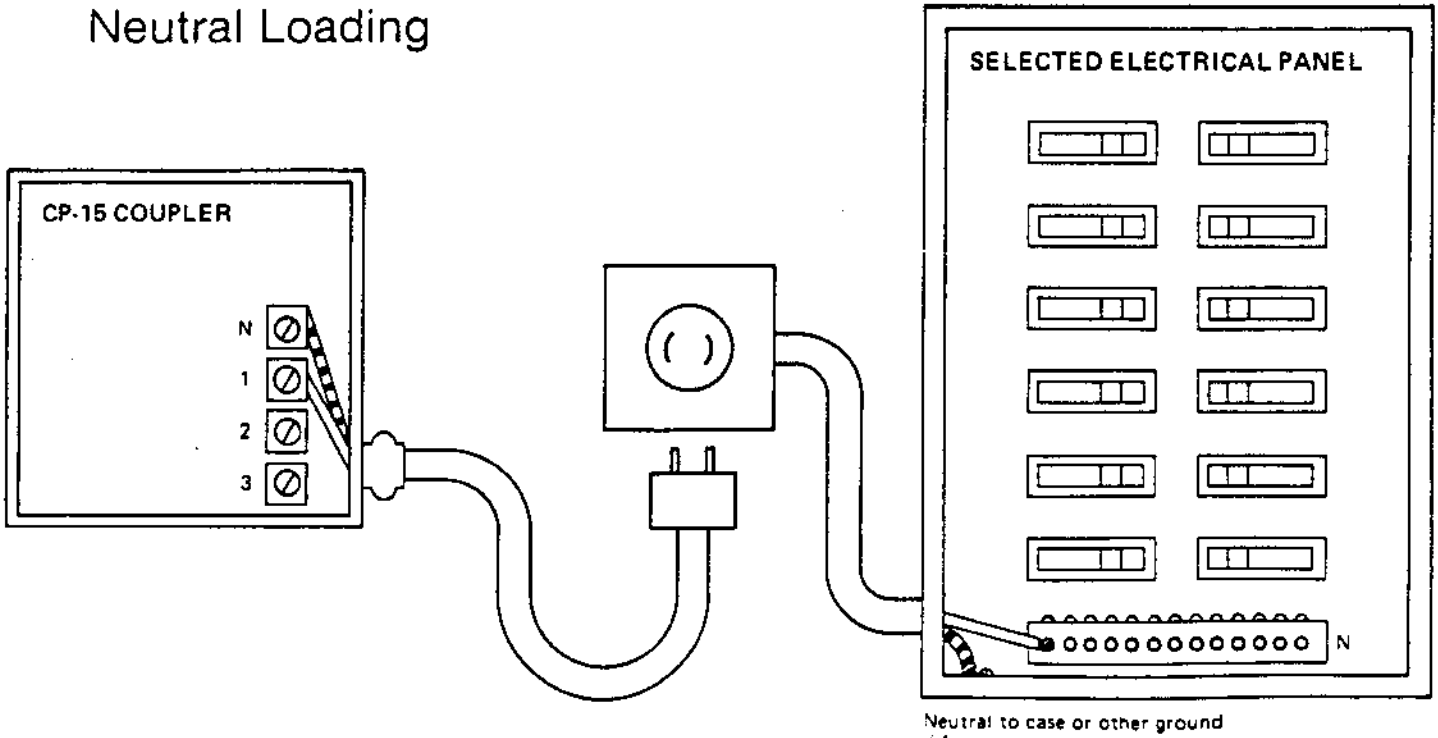
CP-15 COUPLER CONTROL LOCATIONS



Standard Method

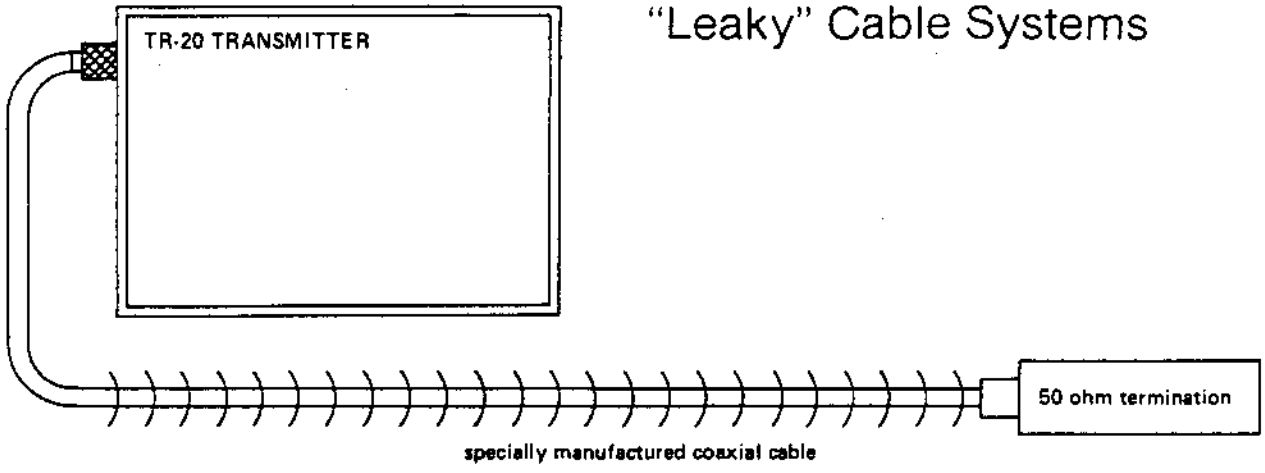


Neutral Loading

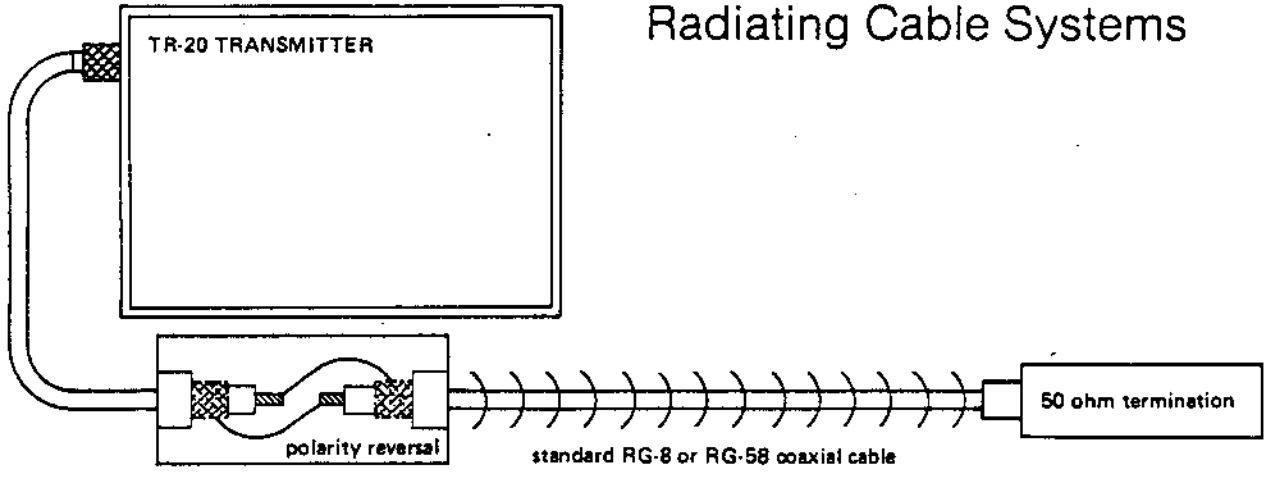


Neutral to case or other ground
1 screw to neutral strip

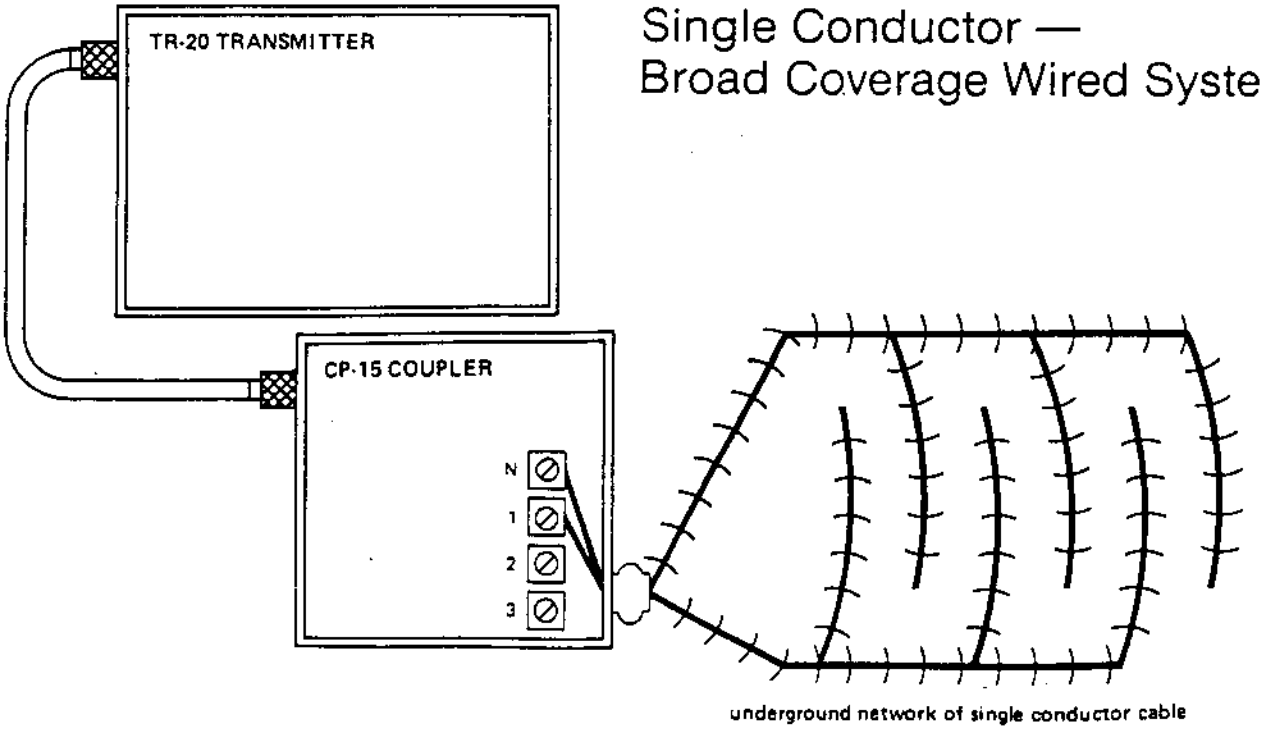
"Leaky" Cable Systems



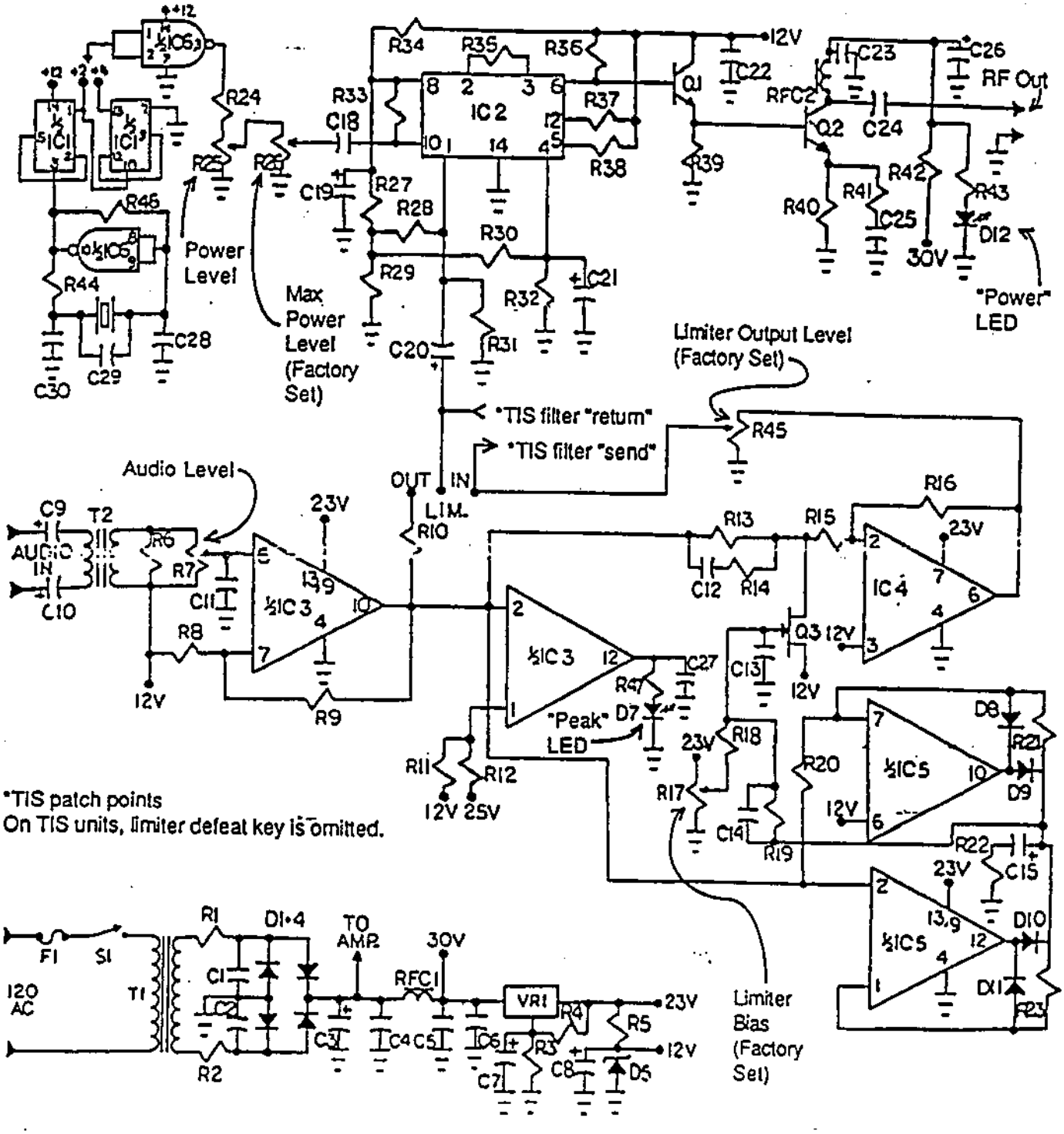
Radiating Cable Systems



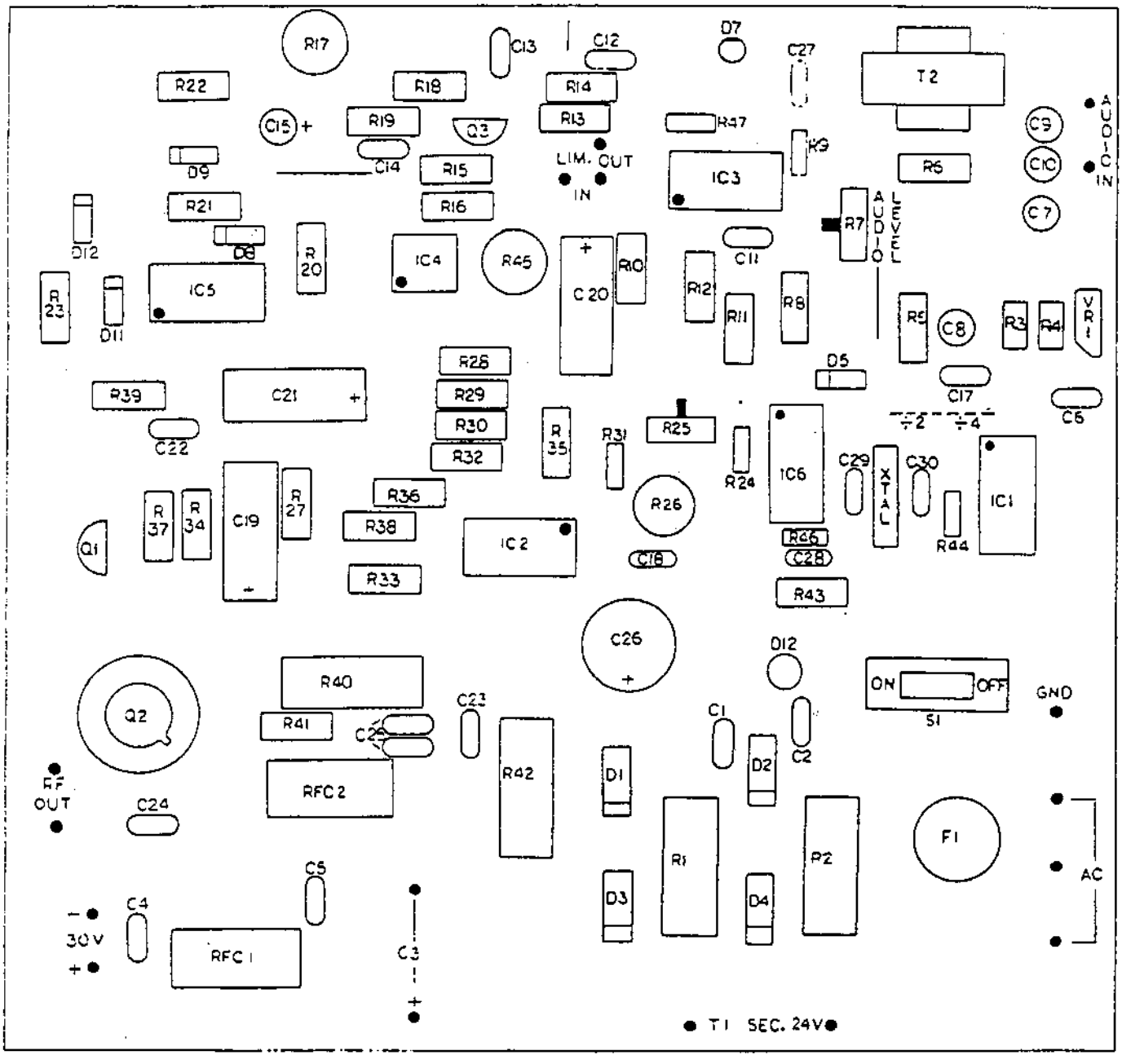
Single Conductor — Broad Coverage Wired System



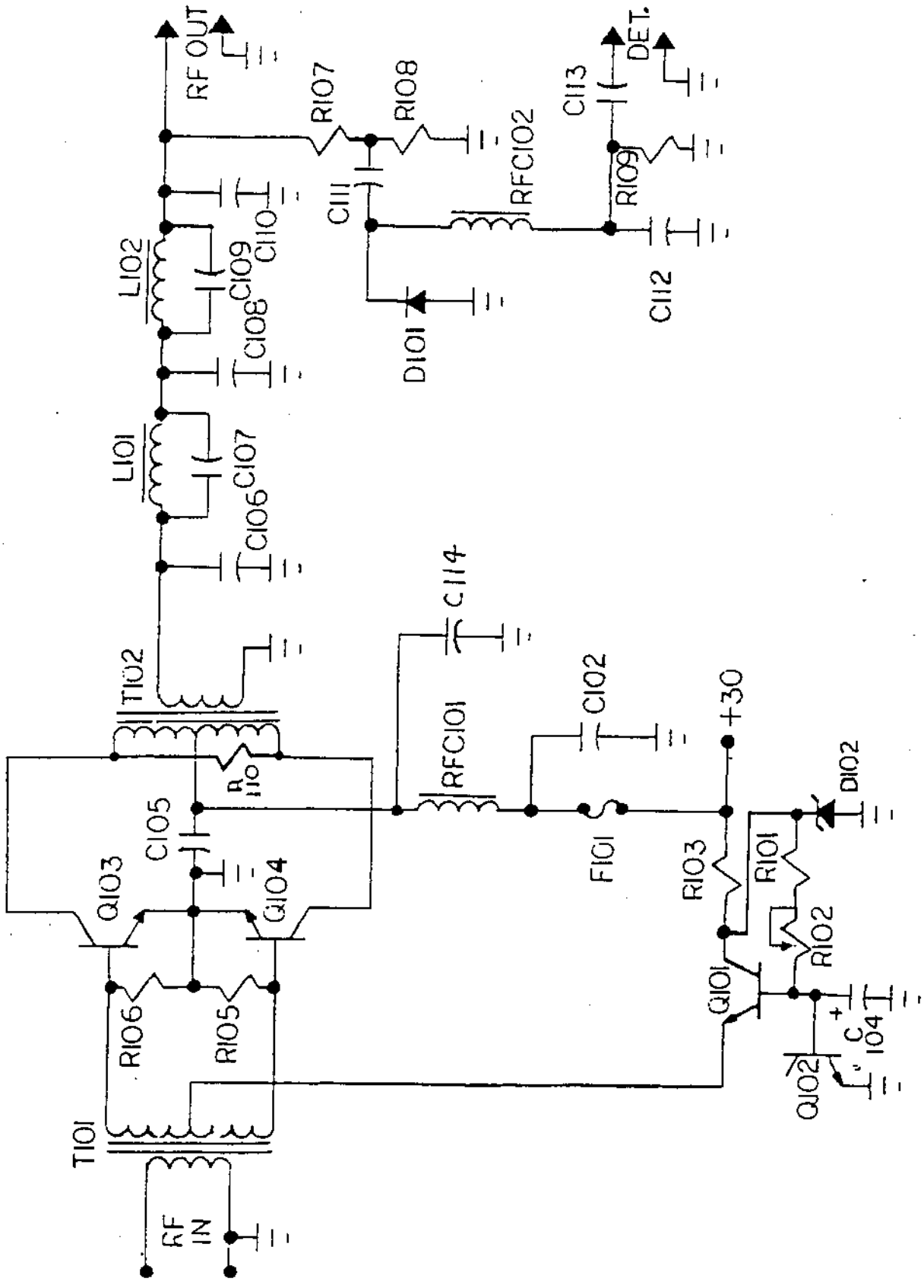
EXCITER/POWER SUPPLY SCHEMATIC



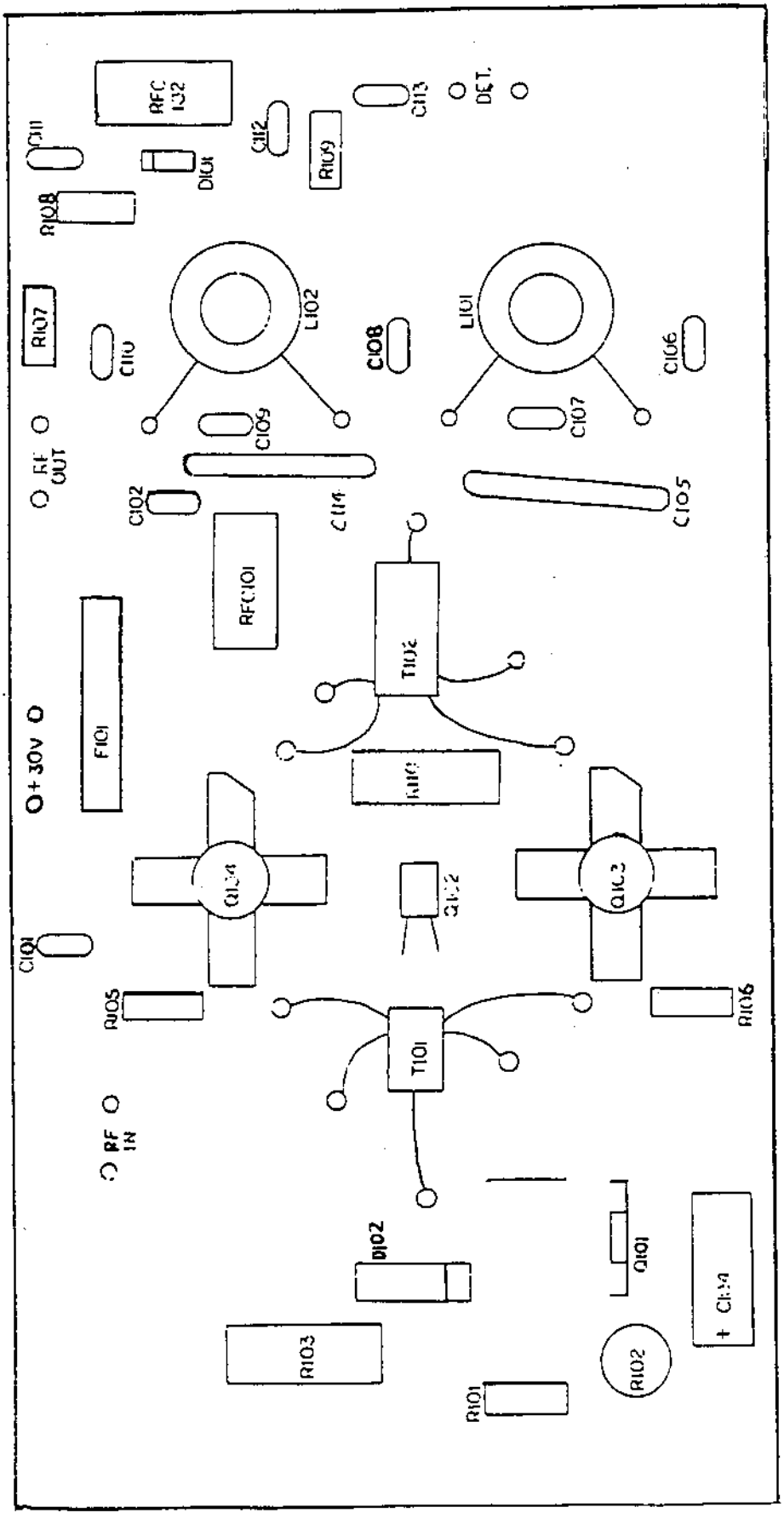
EXCITER/POWER SUPPLY PARTS LAYOUT



AMPLIFIER SCHEMATIC



AMPLIFIER PARTS LAYOUT



TRANSMITTER PARTS LIST

Resistors 1/2w. 5% unless noted
Capacitors in MFD. unless noted

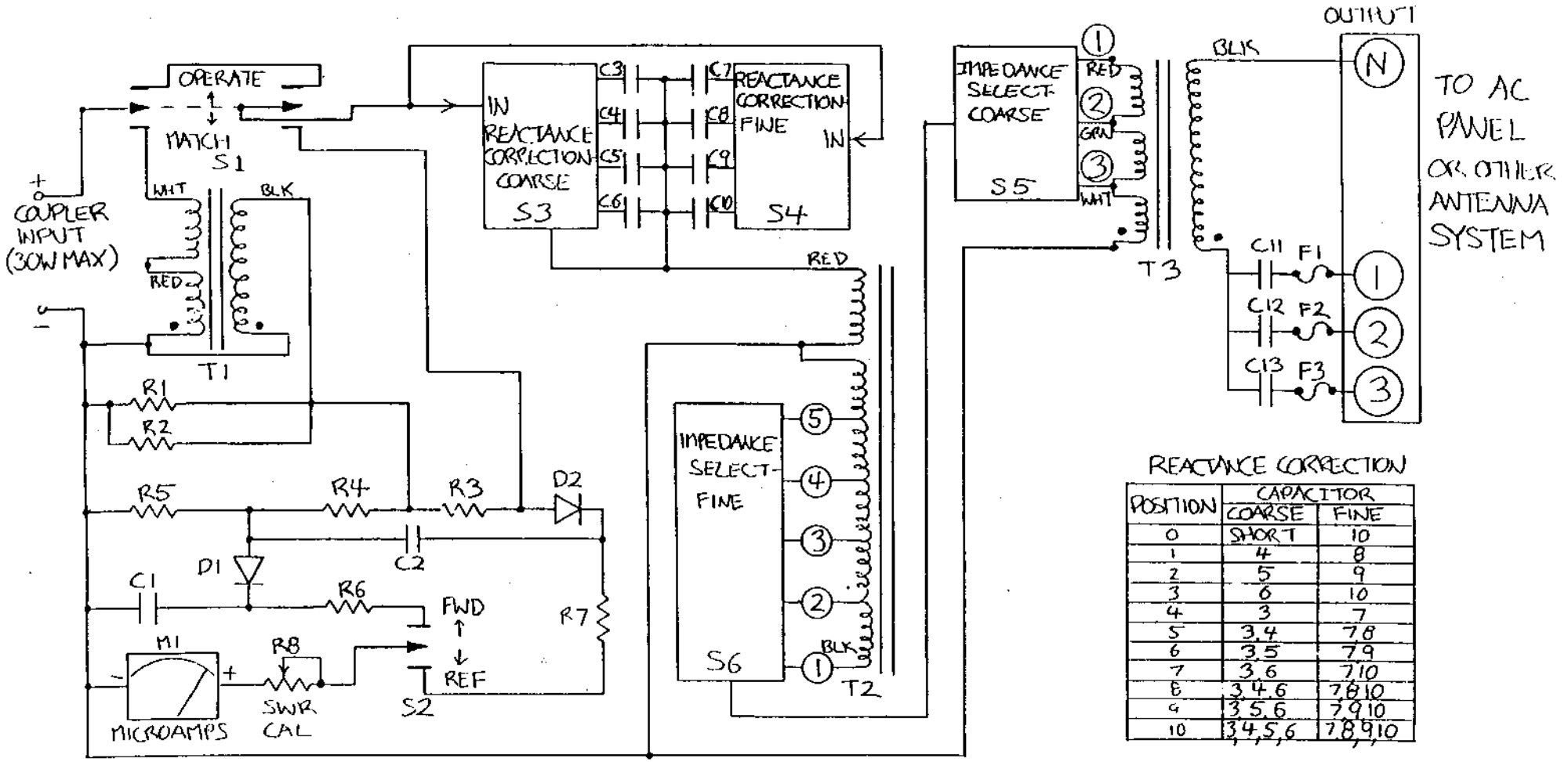
R1	.1 5w
R2	.1 5w
R3	2,260 1%
R4	118 1%
R5	680
R6	680
R7	10,000 pot.
R8	10,000
R9	220,000
R10	820
R11	10,000 2%
R12	510 2%
R13	15,000
R14	47,000
R15	2,000
R16	27,000
R17	10,000 pot.
R18	47,000
R19	100,000
R20	100,000
R21	100,000
R22	10
R23	100,000
R24	4,700
R25	10,000 pot.
R26	10,000 pot.
R27	820
R28	100
R29	1,000
R30	100
R31	47,000
R32	1,800
R33	47
R34	1,300
R35	1,000
R36	3,000
R37	3,000
R38	10,000
R39	10,000
R40	100 5w
R41	6.8
R42	150 5w
R43	1,500
R44	22,000
R45	10,000 pot
R46	10 meg.
R47	1500

R101	470 pot.
R102	10,000 pot.
R103	120 5W
R105	15
R106	15
R107	2,200
R108	2,200
R109	1,500
R110	150 5w
C1	.01
C2	.01
C3	11,000 35V
C4	.1
C5	.1
C6	.1
C7	10 35V
C8	10 35V
C9	10 35V
C10	10 35V
C11	220 PF
C12	.01
C13	.01
C14	.001
C15	4.7 16V
C16	10 PF
C17	.1
C18	.1
C19	100 16V
C20	100 16V
C21	100 16V
C22	.1
C23	.1
C24	.1
C25	.1 + .1
C26	470 35V
C27	.1
C28	18 PF
C29	18 PF
C30	18 PF
C101	.1
C102	.1
C103	100 16V
C104	1,000 6V
C105	2.2
C106-C110	Factory Select
C111	.01
C112	.01
C113	.1
C114	2.2

TRANSMITTER PARTS LIST CONT'D

D1	3 amp 100V
D2	3 amp 100V
D3	3 amp 100V
D4	3 amp 100V
D5	IN4742A 12V
D7	LED
D8	IN4148
D9	IN4148
D10	IN4148
D11	IN4148
D12	LED
D101	1N270
D102	IN5349
F1	2 amp Slo-Blo
F101	4 amp
S1	SPST
RFC1	RSM RF01
RFC2	47 microhy.
RFC101	RSM RF01
RFC102	1MHY.
Q1	2N3904
Q2	2N2868
Q101	2N5296
Q102	2N6037
Q103	RSMQ01
Q104	RSMQ01
IC1	14013
IC2	LM1496
IC3	083
IC4	LF351
IC5	083
IC6	14011
L101, 102	Factory Select
T1	6A 24V
T2	600-600 ohms
T101	RSMT11
T102	RSMT01

XTAL FUND. AT CUT HC6/U



REACTANCE CORRECTION

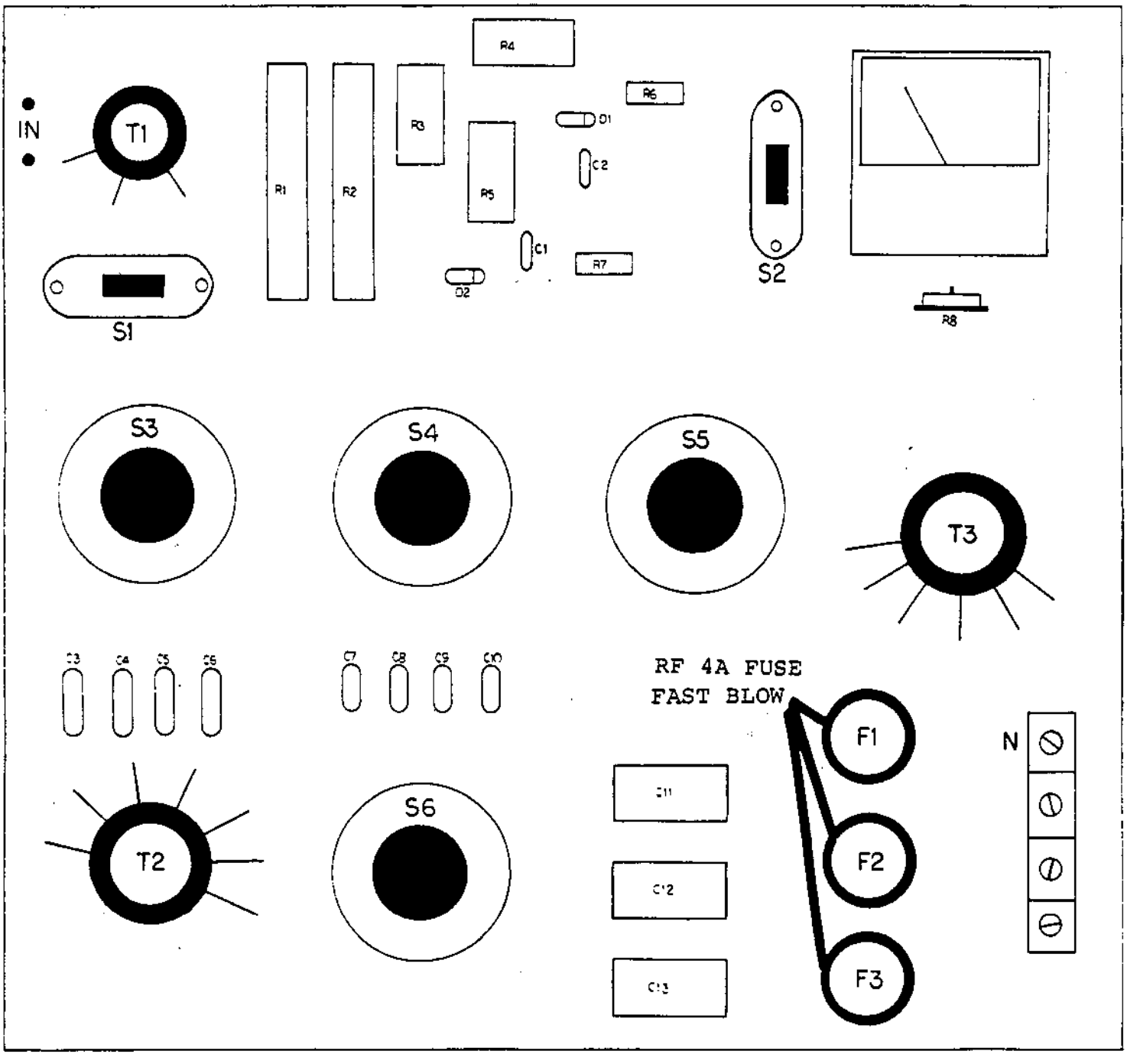
POSITION	CAPACITOR	
	COARSE	FINE
0	SHORT	10
1	4	8
2	5	9
3	6	10
4	3	7
5	3,4	7,8
6	3,5	7,9
7	3,6	7,10
8	3,4,6	7,8,10
9	3,5,6	7,9,10
10	3,4,5,6	7,8,9,10

IMPEDANCE CORRECTION

POSITION	TRANSFORMER TAP	
	COARSE	FINE
1	1	-
2	2	-
3	3	-
4	-	1
5	-	2
6	-	3
7	-	4
8	-	-

CP-15 COUPLER SCHEMATIC

COUPLER PARTS LAYOUT



COUPLER PARTS LIST

R1	25	10w
R2	25	10w
R3	51	2w
R4	47	2w
R5	47	2w
R6	10,000	½w
R7	10,000	½w
R8	100,000	pot
C1	.01 mfd.	
C2	.01 mfd.	
C3	3900 pfd.	500V
C4	1000 pfd.	500V
C5	2000 pfd.	500V
C6	3000 pfd.	500V
C7	390 pfd.	500V
C8	100 pfd.	500V
C9	200 pfd.	500V
C10	300 pfd.	500V
C11	.1 mfd.	600V
C12	.1 mfd.	600V
C13	.1 mfd.	600V
D1	1N270	
D2	1N270	
S1	DPDT	
S2	SPDT	
S3	RSM SCD1	
S4	RSM SCD1	
S5	SP3T	
S6	SP5T	
T1	RSM CI1	
T2	RSM CM1	
T3	RSM CO1	
Meter	RSM CDC3	
F1-F3	4 AMP	