INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY – 10 WATT / 1 WATT / 10 WATT

CAUTION: It is recommended that the user of this equipment become thoroughly familiar with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

A widely used high speed relaying system used for transmission line protection consists of directional-comparison unblock relaying plus a transfer-trip channel for breaker failure protection. Normally these systems of relaying require two frequency-shift channels, wideband for unblocking and narrowband for transfer trip. A saving in channel spectrum can be effected by using a three frequency transmitter for the two relaying functions and two separate receivers, one for each function, as shown in Figure 7.

SYSTEM OPERATION

The three frequency TCF carrier transmitter provides for the transmission of any of three closely controlled discrete frequencies, all within the equivalent spacing of a single wide-band channel. The center frequency of the channel can vary from from 30 kHz to 300 kHz in 0.5 kHz steps. The transmitter normally operates at a frequency that is 100 hz above the channel center frequency (fc). This frequency serves as the "guard" frequency for the transfer-trip receiver and as the "block" frequency for the unblock receiver. Note that the discriminator characteristic in the unblock receiver in this case is reversed from the normal unblock receiver used with the standard two frequency transmitter. This "guard" "block" frequency is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and serves to prevent false operation of the receiver by line noise. The lowest frequency, which is 100 hz less than fc, is the "transfer trip" frequency and is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line. The highest frequency, which is 300 hz above fc, is the "unblock" frequency and is transmitted as an unblock signal for directional comparison relaying. If a subsequent transfer-trip operation is called for, the transmitter will shift to fc - 100 hz which is the "trip" frequency for the transfer trip (narrow-band receiver.

Note that when the transmitter shifts to "unblock," the frequency is completely outside the passband of the narrow band transfer-trip receiver. Normally, this would cause a low-signal alarm output from that receiver. Similarly, when the frequency is shifted to "trip" (fc-100 hz), the signal is well removed from the "block" peak of the wide-band receiver discriminator. In order to prevent a similar alarm output in this case, the checkback output of each receiver is cross-connected to the guard or block input of the opposite receiver (through an OR logic circuit). This logic is shown in Figure 8. The checkback output is a receiver output that indicates that a proper signal has been received without going through any time delays or other logic used for the actual relaying output. With this cross-connected logic, both receivers will function when required, but will not give any incorrect output indications.

The transmitter normally operates at an output level of one watt at the "guard" "blocking" frequency, but increases to ten watts for either "trip" or "unblock" output. An interlock is provided in the transmitter keying circuit to give transfer-trip preference. This means that even while the transmitter is shifted to the "unblock" frequency, if the transfer-trip keying circuit is energized, the transmitter will shift to the "trip" frequency without delay.

CHARACTERISTICS

Frequency Range	30-300 kHz
Output	1 watt guard- 10 watts transfer trip (into 50 to 70 ohm resistive load) – 10 watts unblock.
Frequency Stability	±10 hz from -20°C to +55°C.
Frequency Spacing	3000 hz min. between transmitter and adjacent receiver frequencies.
Harmonics	Down 55 db (min.) from output level.
Input voltage	48 or 125 v.d.c.
Supply voltage variation	42-56 v. for nom. 47 v. supply. 105-140 v. for nom. 125 v. supply.
Battery drain	0.5 a. guard, 1.15 a. trip – 48 v.d.c.
	0.5 a. guard, 1.15 a. trip – 125 v.d.c.
Keying circuit current	4 ma.
Temperature range	–20 to +55°C. Around chassis.
Dimensions	Panel height - 12¼" or 7 r.u. Panel width - 19"
Weight	12 lbs.

INSTALLATION

The TCF transmitter is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

The TCF 10W/1W/10W 3 frequency transmitter is shipped with the power output controls R64 and R70 set for outputs of 1 watt and 10 watts into a 60 ohm load. If it is desired to check these adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 10 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T4 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table. For above 200 kHz, tuning coil L105 is a screw type adjustment and not a plunger with knurled shaft and locking nut.

Then change to Trip frequency by connecting together terminals 2 and 3 of the transmitter printed circuit board (which is approximately equivalent to connecting together terminals 7 and 8 of J3), and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch, remove the jumper used to key the transmitter to the 10 watt level, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

T106 Tap	Voltage for 1 Watt Output	Voltage for 10 Watts Output
50	7.1	22.4
60	7.8	24.5
70	8.4	26.5

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 MHz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed, the Guard adjustment should be made with capacitor C52 and the Trip adjustment with C53.

MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in the following tables. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

TABLE I
TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

Test Point	Voltage at 1 Watt Output	Voltage at 10 Watts Output
TP52	20	20
TP53	5.4	5.4
TP54	3.4	3.4
TP55	21	18.5
TP56	21	18.5
TP57	*< 1.0	*< 1.0
TP58	44.3	44.1
TP59	*< 1.0	*< 1.0
TP101	0	0
TP103	21 ± 2	21 ± 2
TP105	44.3	44.0

TABLE II
TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with a-c VTVM.

Test Point	Voltage at 1 Watt Output	Voltage at 10 Watts Output
TP54 to TP51	0.015 – 0.03	0.015 – 0.03
TP57 to TP51	0.05 – 0.09	0.3 – 1.2
TP59 to TP51	0.05 – 0.09	0.3 – 1.2
T1-1 to TP51	1.65	5.6
T1-3 to TP51	1.45	4.9
T1-4 to Gnd.	.6	2.0
T2-1 to Gnd.	.57	1.85
TP101 to TP103	5.2	17.0
TP103 to TP105	5.2	17.0
T3-4 to Gnd.	35	112
T4-2 to Gnd.	31	110
TP109 to Gnd.	9.8	31
J102 to Gnd.	7.8	24.5

CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlay is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5	207.1-214.0
32.0-33.5	64.5- 68.0	120.0-127.0	214.1-222.0
34.0-36.0	68.5- 72.0	127.5-135.0	222.1-230.0
36.5-38.5	72.5- 76.0	135.5-143.0	230.1-240.0
39.0-41.0	76.5- 80.0	143.5-151.0	240.1-250.0
41.5-44.0	80.5- 84.5	151.5-159.5	250.1-262.0
44.5-47.0	85.0- 89.0	160.0-169.5	262.1-274.0
47.5-50.0	89.5- 94.5	170.0-180.0	274.1-287.0
50.5-53.5	95.0-100.0	180.5-191.5	287.1-300.0
54.0-57.0	100.5-106.0	192.0-220.0	
57.5-60.5	106.5-112.5	200.1-207.0	

If the new frequency lies within the same frequency group as the original frequency, the filters can be readjusted. If the frequencies are in different groups, it is possible that changes only in the fixed capacitors may be required. In general, however, it is desirable to order complete filter assemblies adjusted at the factory for the specified frequency.

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 3 volts output. The core screw of the small inductor should be turned to the position that gives a true maximum reading on the VTVM. Turning the screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel than when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inductance occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor, L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500 ohm resistor.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarly, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion losses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. 60-ohm 10-watt non-inductive resistor.

b. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 hz to 330-kHz; input impedance 7.5 megohms.

c. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:	1.5 to 300 volts.
Input Impedance:	7.5 megohms.

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator

Output Voltage	up to 8 volts.
Frequency Range:	20-kHz to 330-kHz.

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19'' rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.45 mfd.; 330 V.A.C.	1723408
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C3	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized Paper, .047 mfd.;	849A437H04
C21	Metallized Paper, .047 mfd.;	849A437H04
C51	Dur-Mica, 1500 pf.; 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable 5.5 -18 pf.	879A834H01
C54	Metallized paper, .1 mfd.; 200 V.D.C.	187A624H01
C55	Variable, 5.5-18 pf.	762A736H01
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd,; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf.; 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf.; 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C66	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd., 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd., 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd., 200 V.D.C.	187A624H02
C70	3 pf.	861A846H03
C71	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C72	Dur-Mica, 300 pf, 500 V.D.C.	187A584H09
C73	Variable, 5.5-18 pt.	879A834H01
C74	3 pf.	861A846H03
C75	3 pf.	861A846H03
C76	3 pf.	861A846H03
C101	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C102	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C103 & C104	(30-50 KC) – Extended foil, 0.47 mfd.; 400 V.D.C.	188A293H01
C103 & C104	(50.5-75 KC) – Extended foil, 0.22 mfd.; 400 V.D.C.	188A293H02
C103 & C104	(75.5 - 100 KC) – Extended foil, 0.15 mfd., 400 V.D.C.	188A293H03
C103 & C104	(100.5 - 150 KC) – Extended foil, 0.10 mfd., 400 V.D.C.	188A293H04
C103 & C104	(150.5 - 300 KC) – Extended foil, 0.047 mfd.; 400 V.D.C.	188A293H05
	DIODES – GENERAL PURPOSE	
D11	1N645A	837A692H03
D12	1N645A	837A692H03
D13	1N4822	188A342H11
D14	1N4822	188A342H11

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
D15	1N4822	188A342H11
D16	1N4822	188A342H11
D21	1N645A	837A692H03
D22	1N4822	188A342H11
D23	1N4822	188A342H11
D24	1N4822	188A342H11
D25	1N4822	188A342H11
D51	1N628; 125 V.; 30 MA.	184A885H12
D52	1N628; 125 V., 30 MA.	184A885H12
D53	1N457A; 60 V., 200 MA.	184A885H07
D55	1N628; 125V; 30 MA.	184A885H12
D56	1N628; 125 V., 30 MA.	184A885H12
D57	1N457A; 60 V., 200 MA.	184A885H07
D101	1N538; 200 V.; 750 MA.	407C703H03
D102	1N91; 100 V., 150 MA.	182A881H04
D103	1N538; 200 V., 750 MA.	407C703H03
D104	1N91; 100 V.; 150 MA.	182A881H04
	DIODES – ZENER	
Z1	1N2828B; 45V. ±5%; 50 W.	184A854H06
Z2	1N3009A; 130 V. ±10%; 10 W.	184A617H12
Z11	1N957B	186A797H06
Z12	1N3688A	862A288H01
Z13	1N3688A	862A288H01
Z14	1N3686B	185A212H06
Z21	1N957B	186A797H06
Z22	1N3688A	862A288H01
Z23	1N3688A	862A288H01
Z24	1N3686B	185A212H06
Z54	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
Z105	1N2999A; 56 V. ±10%; 10 W.	184A617H13
Z106	1N2999A; 56 V. ±10%; 10 W.	184A617H13
	RESISTORS	
R1	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R2	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R3	26.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H44
R3	500 ohms ±5%; 40 W. (For 125 V Supply)	1268047
R4	100 ohms ± 10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
R11	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R12	12K ±2%; ½ W. Metal Glaze	629A531H58
R13	10K ±2%; ½ W. Metal Glaze	629A531H56

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R14	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R15	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R16	47K ±2%; ½ W. Metal Glaze (For 125 Vdc)	629A531H72
R17	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R21	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R22	12K ±2%; ½ W. Metal Glaze	629A531H58
R23	10K ±2%; ½ W. Metal Glaze	629A531H56
R24	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R25	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R26	15 K ±2%; ½ W. Metal Glaze (For 48 Vdc)	629A531H60
R27	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R51	10K ±5%; ½ W. Composition	184A763H51
R52	10K ±5%; ½ W. Composition	184A763H51
R53	10K ±5%; ½ W. Composition	184A763H51
R54	10K ±5%; ½ W. Composition	184A763H51
R55	100 ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K; ¼ W.	629A430H02
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms ±5%; ½ W. Composition	184A859H06
R70	Potentiometer, 1K; ¼ W.	629A430H02
R71	4.7K ±5%; ½ W. Composition	184A763H43
R72	39K ±5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06
R74	180 Ohms ±5%; ½ W. Composition	184A763H02
R75	100 ohms ±5%; ½ W. Composition	184A763H03
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R79	20K ±20%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ± 20%; ¼ W.	629A430H09
R81	1K ±1%l ½ W. Metal Film	849A819H48

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R82	5K Pot. ± 20%; ½ W.	629A430H07
R83	10.2K ± 1%; ½ W. Metal Film	848A820H46
R84	27 Ohms ± 5%; ½ W. Composition	187A290H11
R85	Thermistor 3D402 10 ohms	185A211H03
R86	750 ohms ± 1%; ½ W. Metal Film	848A819H36
R87	10K ± 5%; ½ W. Composition	184A763H51
R101	10 ohms ±5%; ½ W. Composition	187A280H01
R102	2.2K ±10%; 1 W. Composition	187A644H35
R103	2.7 ohms ±10%; ½ W. Wire Wound	184A636H14
R104	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
R105	10 ohms ±5%; ½ W. Composition	187A290H01
R106	4.7K ±10%; 1 W. Composition	187A644H43
R107	2.7 ohms ±10%; ½ W. Wire Wound	184A636H14
R108	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
	TRANSFORMERS	
T1	Driver Output Transformer	606B410G01
T2	Power Amp. Input Transformer	292B526G01
T3	Power Amp. Output Transformer	292B526G02
T4	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	606B537G01
T52	Driver Input Transformer	606B537G02
	TRANSISTORS	
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q21	2N4356	849A441H02
Q22	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q55	2N697	184A638H18
Q56	2N2726	762A672H07
Q57	2N2726	762A672H07
Q101	2N1908 (Use in Matched Pairs)	187A673H02
Q102	2N1908 (Use in Matched Pairs)	187A673H02
	MISCELLANEOUS	
Y1-Y2	Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing	408C743
FL101	Driver Filter	408C261 + (Req. Freq.)
FL102	Output Filter	541D214 + (Req. Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02
	Pilot Light Bulb - For 125 or 250 V. Supply (When supplied)	183A955H01
F1, F2	Fuse, 1.5A (When supplied)	11D9195H26

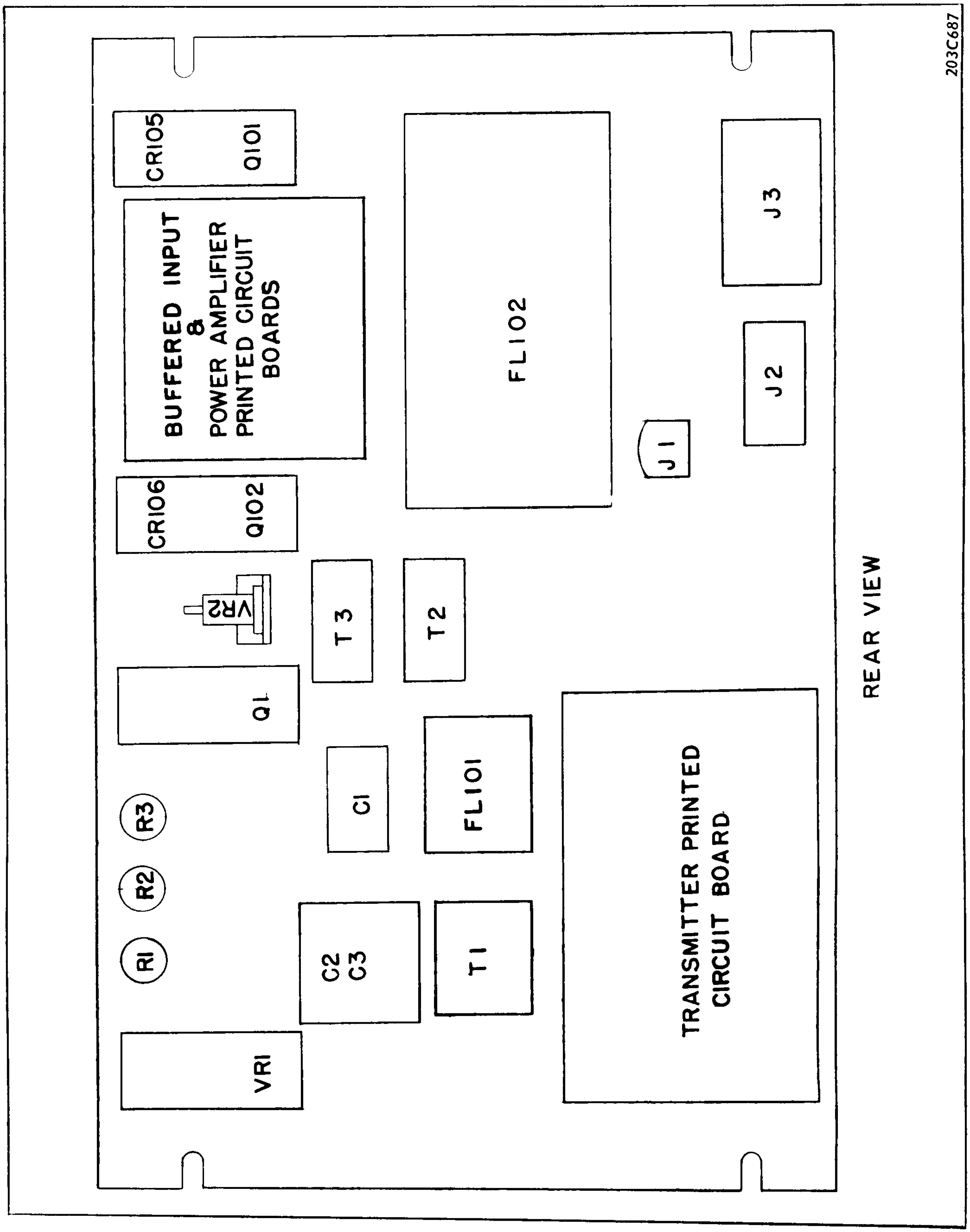

Fig. 2. Component locations of the type TCF Transmitter Assembly.

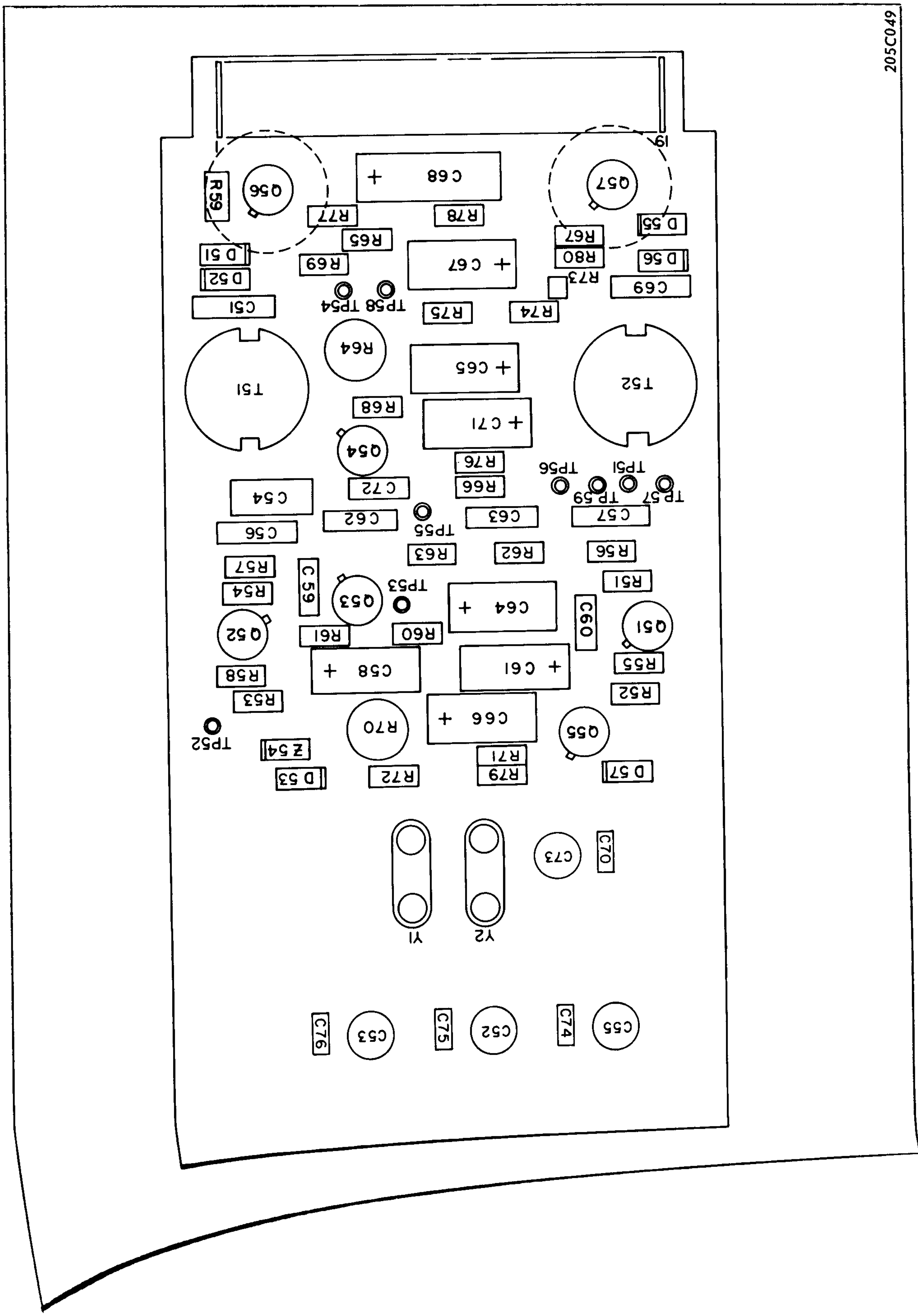

Fig. 3. Component Locations of the Transmitter Printed Circuit Board.

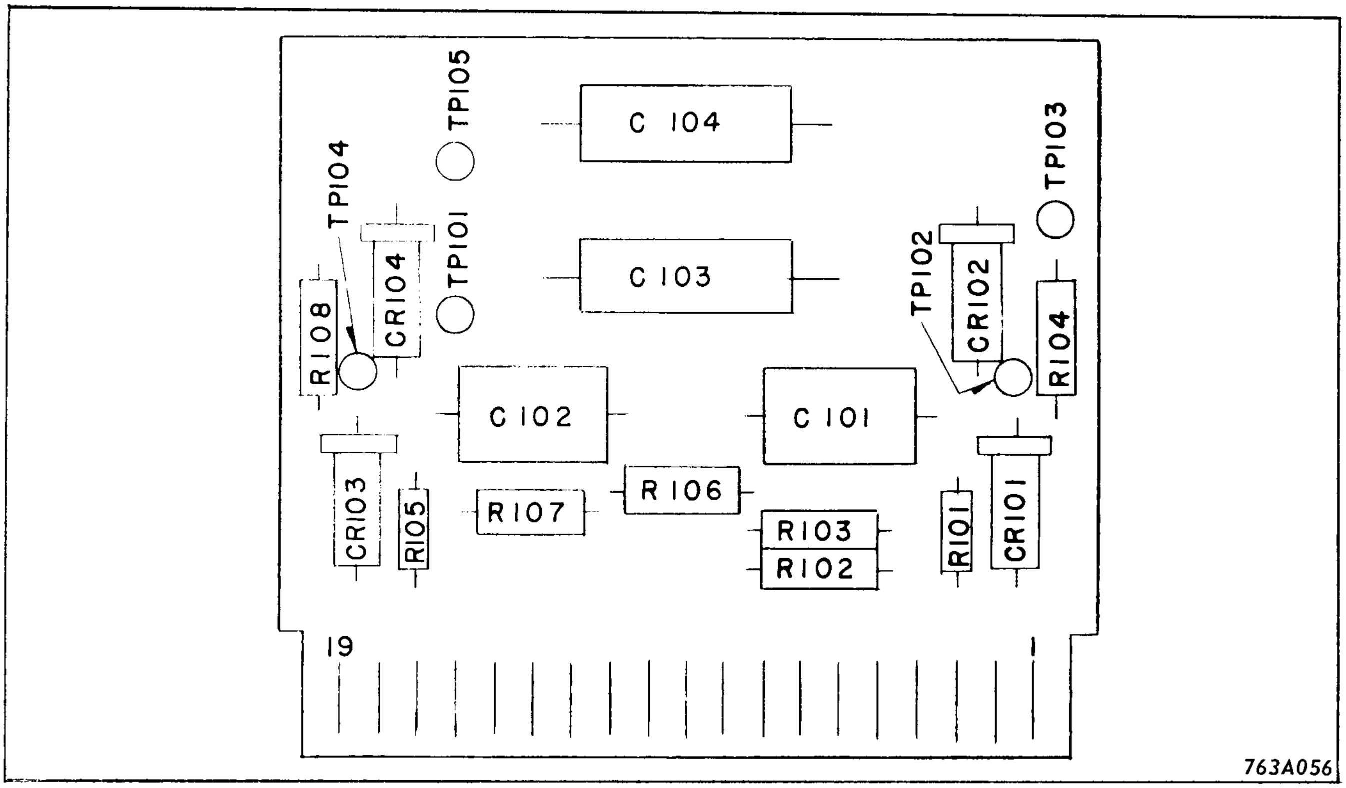

Fig. 4. Component Locations of the Power Amplifier Printed Circuit Board

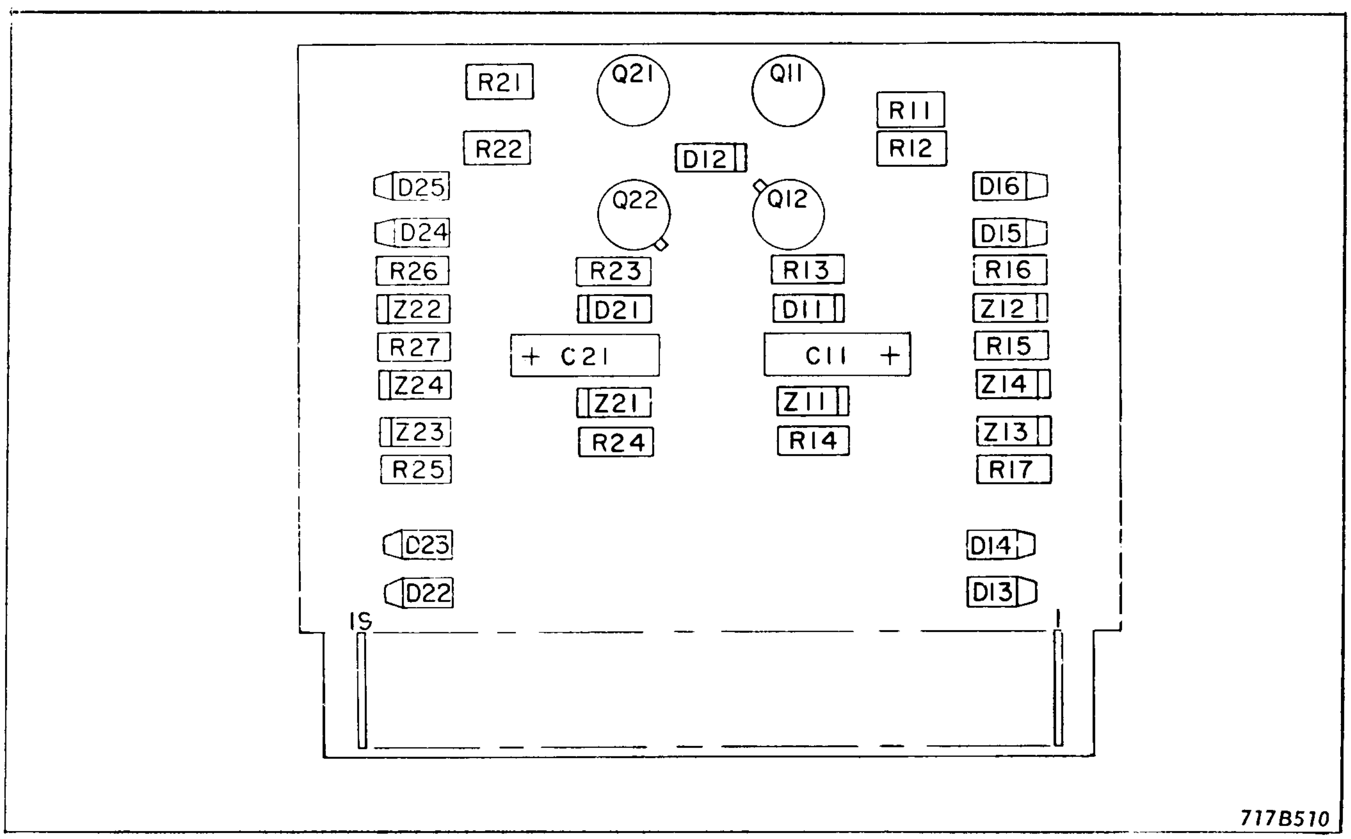

Fig. 5. Component Location of Buffer Keying Circuit Board

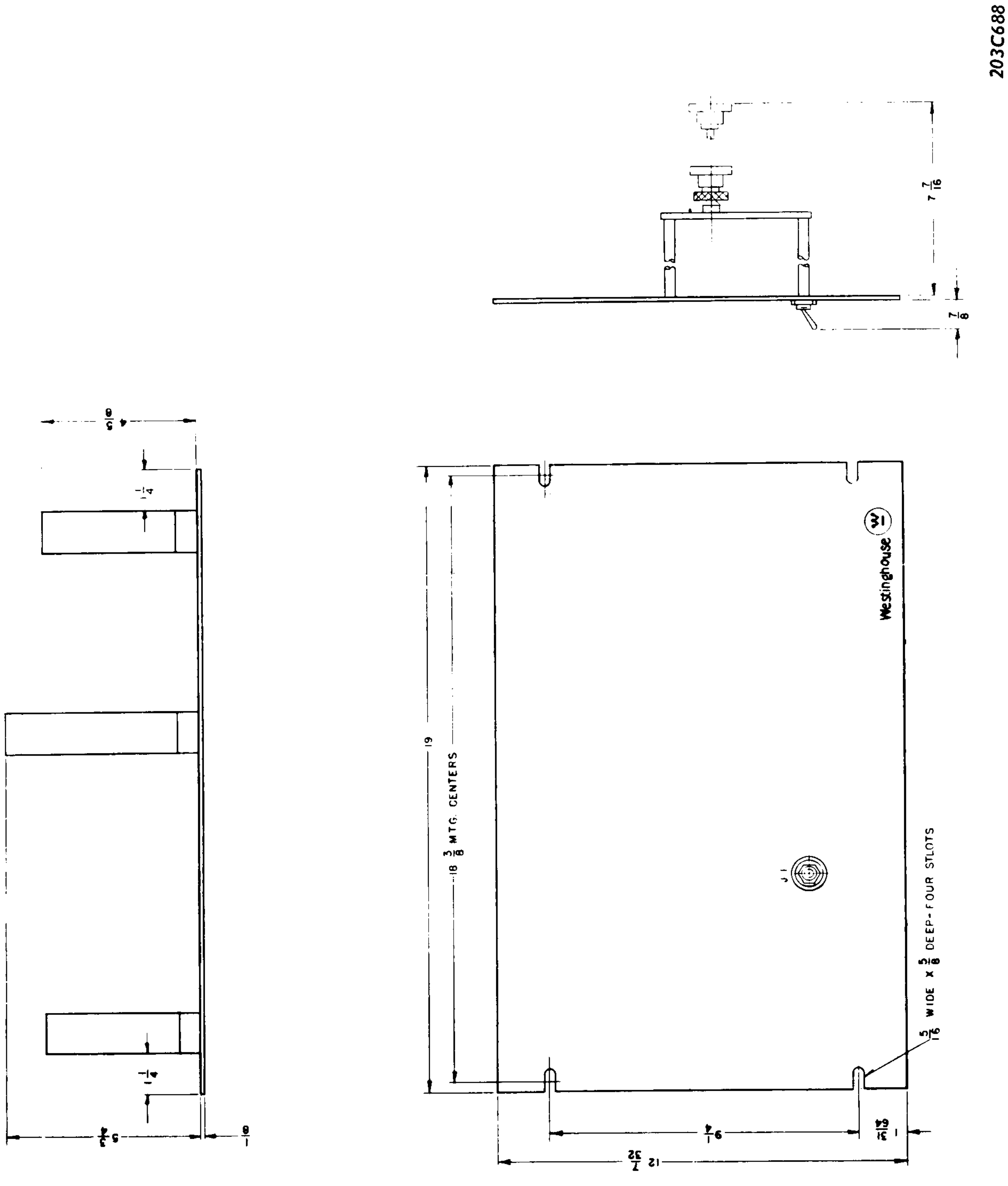

Fig. 6. Outline and Drilling Plan for the Type TCF Transmitter Assembly

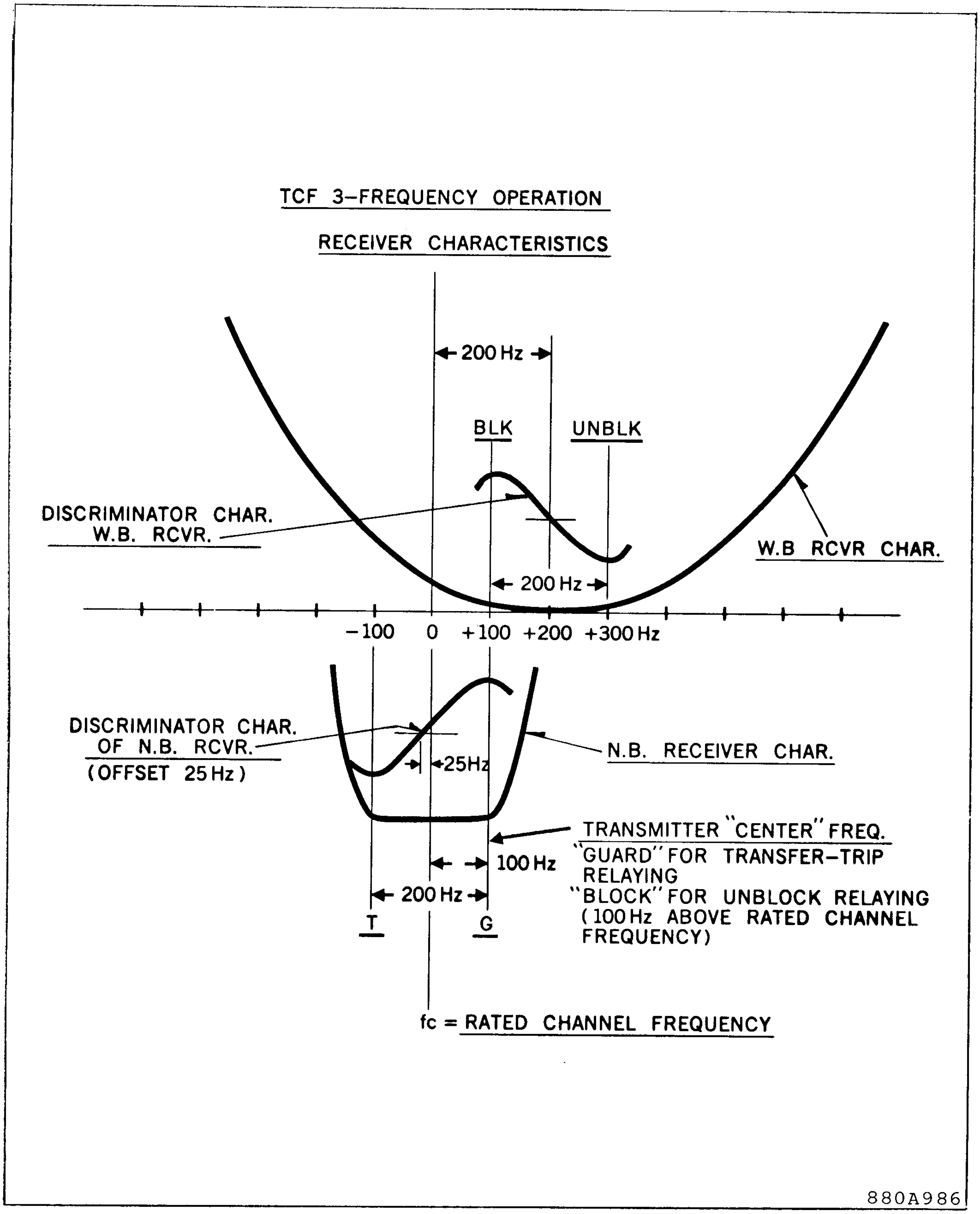

Fig. 7. Three Frequency Operation — Receiver Characteristics

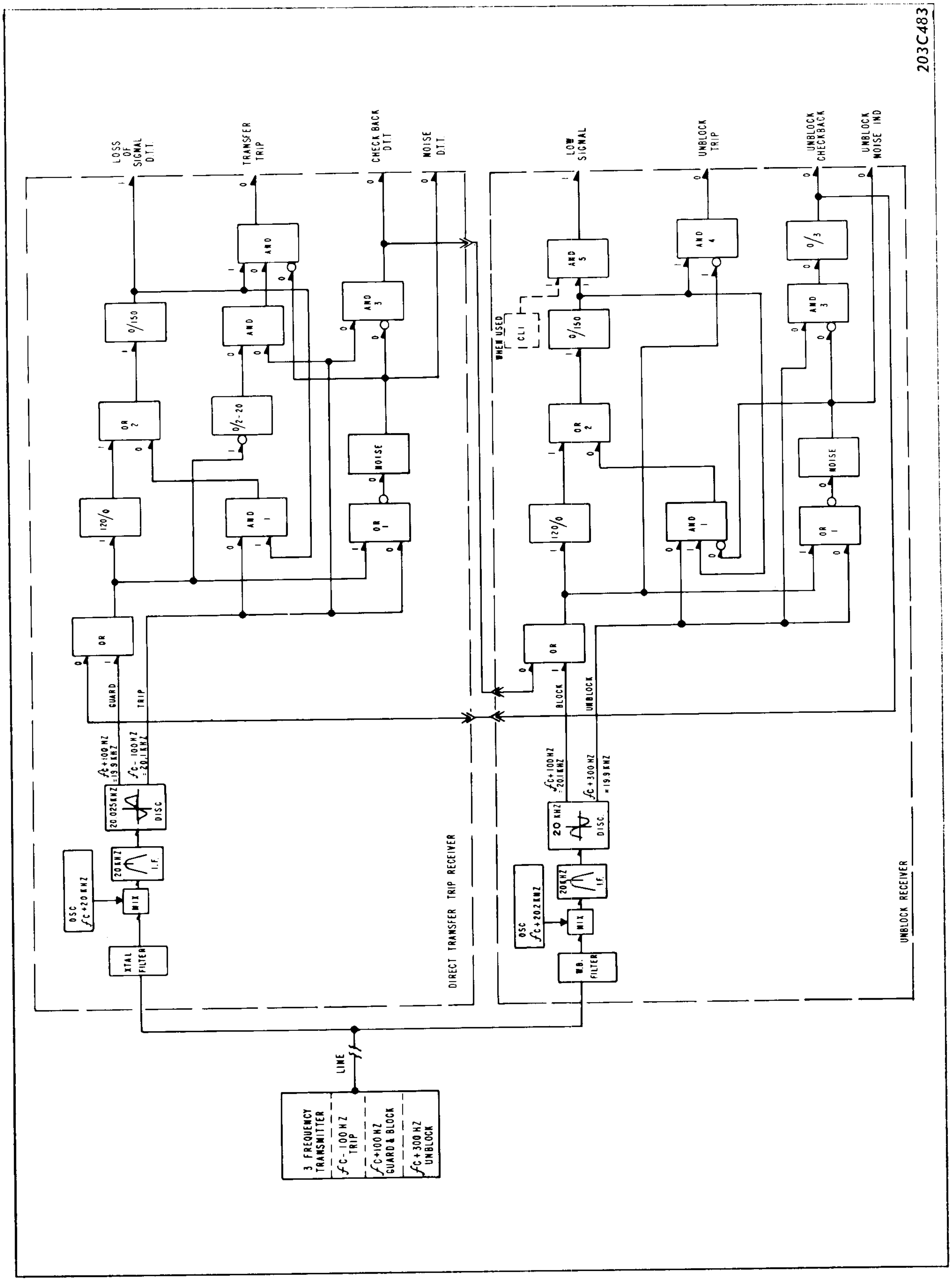

Fig. 8. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION NEWARK, N. J.

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY - 10 WATT / 1 WATT / 10 WATT

CAUTION: It is recommended that the user of this equipment become thoroughly familiar with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

A widely used high speed relaying system used for transmission line protection consists of directional-comparison unblock relaying plus a transfer-trip channel for breaker failure protection. Normally these systems of relaying require two frequency-shift channels, wideband for unblocking and narrowband for transfer trip. A saving in channel spectrum can be effected by using a three-frequency transmitter for the two relaying functions and two separate receivers, one for each function, as shown in Figure 7.

SYSTEM OPERATION

The three-frequency TCF carrier transmitter provides for the transmission of any of three closely controlled discrete frequencies, all within the equivalent spacing of a single wide-band channel. The center frequency of the channel can vary from 30 kHz to 300 kHz in 0.5-kHz steps. The transmitter normally operates at a frequency that is 100 Hz above the channel center frequency (fc). This frequency serves as the "guard" frequency for the transfer-trip receiver and as the "block" frequency for the unblock receiver. Note that the discriminator characteristic in the unblock receiver in this case is reversed from the normal unblock receiver used with the standard two-frequency transmitter. This "guard" or "block" frequency is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and serves to prevent false operation of the receiver by line noise. The lowest frequency, which is 100 Hz less than fc is the "transfer trip" frequency and is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line. The highest frequency, which is 300 Hz above fc, is the "unblock" frequency and is transmitted as an unblock signal for directional-comparison relaying. If a subsequent transfer-trip operation is called for, the transmitter will shift to fc -100 Hz which is the "trip" frequency for the transfer-trip (narrow-band) receiver.

Note that when the transmitter shifts to "unblock," the frequency is completely outside the passband of the narrow band transfer-trip receiver. Normally, this would cause a low-✪ signal alarm output from that receiver. In order to prevent an alarm output in this case, the checkback output of the unblock receiver is cross-connected to the guard or block input of the transfer-trip receiver (through on OR logic circuit). This logic is shown in Figures 8 and 9. The checkback output is a receiver output that indicates that a proper signal has been received without going through any time delays or other logic used for the actual relaying output. With this cross-connected logic, both receivers will function when required, but will not give any incorrect output indications.

The transmitter normally operates at an output level of one watt at the "guard" or "blocking" frequency, but increases to ten watts for either "trip" or "unblock" output. An interlock is provided in the transmitter keying circuit to give transfer-trip preference. This means that even while the transmitter is shifted to the "unblock" frequency, if the transfer-trip keying circuit is energized, the transmitter will shift to the "trip" frequency without delay.

CONSTRUCTION

The 10 watt/1 watt/10 watt TCF transmitter unit is mounted on a standard 19-inch wide panel 12¼ inches (7 rack units) high with edge slots for mounting on a standard relay rack. A jack for metering the amplifier collector current is accessible from the front of the panel. See Fig. 6. All of the circuitry that is suitable for printed circuit board mounting is on two such boards, as shown in Fig. 2. The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 1. The location of components on the three printed circuit boards are shown on separate illustrations, Fig. 3, 4 & 5.

Supersedes I.L. 41-945.12, dated July 1971
✪ Denotes change from superseded issue.

EFFECTIVE JUNE 1976

coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T4 output lead to the corresponding tap. Connect an ac vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the dc voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table. For above 200 kHz, tuning coil L105 is a screw type adjustment and not a plunger with kunrled shaft and locking nut.

Then change to Trip frequency by connecting together terminals 2 and 3 of the transmitter printed circuit board (which is approximately equivalent to connecting together terminals 7 and 8 of J3), and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch, remove the jumper used to key the transmitter to the 10 watt level, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

T106 Tap	Voltage for 1 Watt Output	Voltage for 10 Watts Output
50	7.1	22.4
60	7.8	24.5
70	8.4	26.5

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L015. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 MHz can be connected from TP51 and TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed, the Guard adjustment should be made with capacitor C52 and the Trip adjustment with C53.

✪ Q56-Q57 BIAS ADJUSTMENT

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have been changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range dc milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (−). Turn the slotted control on the small potentiometer to full counterclockwise. Now, apply power to the TCF carrier set, but do not transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.2 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply dc power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in the following tables. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

TABLE I
TRANSMITTER DC MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with dc VTVM.

Test Point	Voltage at 1 Watt Output	Voltage at 10 Watts Output
TP52	20	20
TP53	5.4	5.4
TP54	3.4	3.4
TP55	21	18.5
TP56	21	18.5
TP57	<1.0	<1.0
TP58	44.3	44.1
TP59	<1.0	<1.0
TP101	0	0
TP103	21 ± 2	21 ± 2
TP105	44.3	44.0

TABLE II
TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with ac VTVM.

Test Point	Voltage at 1 Watt Output	Voltage at 10 Watts Output
TP54 to TP51	0.015 - 0.03	0.015 - 0.03
TP57 to TP51	0.05 - 0.09	0.3 - 1.2
TP59 to TP51	0.05 - 0.09	0.3 - 1.2
T1-1 to TP51	1.65	5.6
T1-3 to TP51	1.45	4.9
T1-4 to Gnd.	.6	2.0
T2-1 to Gnd.	.57	1.85
TP101 to TP103	5.2	17.0
TP103 to TP105	5.2	17.0
T3-4 to Gnd.	35	112
T4-2 to Gnd.	31	110
TP109 to Gnd.	9.8	31
J102 to Gnd.	7.8	24.5

CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlay is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5	207.1-214.0
32.0-33.5	64.5- 68.0	120.0-127.0	214.1-222.0
34.0-36.0	68.5- 72.0	127.5-135.0	222.1-230.0
36.5-38.5	72.5- 76.0	135.5-143.0	230.1-240.0
39.0-41.0	76.5- 80.0	143.5-151.0	240.1-250.0
41.5-44.0	80.5- 84.5	151.5-159.5	250.1-262.0
44.5-47.0	85.0- 89.0	160.0-169.5	262.1-274.0
47.5-50.0	89.5- 94.5	170.0-180.0	274.1-287.0
50.5-53.5	95.0-100.0	180.5-191.5	287.1-300.0
54.0-57.0	100.5-106.0	192.0-220.0	
57.5-60.5	106.5-112.5	200.1-207.0	

If the new frequency lies within the same frequency group as the original frequency, the filters can be readjusted. If the frequencies are in different groups, it is possible that changes only in the fixed capacitors may be required. In general, however, it is desirable to order complete filter assemblies adjusted at the factory for the specified frequency.

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 3 volts output. The core screw of the small inductor should be turned to the position that gives a true maximum reading on the VTVM. Turning the screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel than when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inducatnce occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor, L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500 ohm resistor.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarly, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion losses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. 60-ohm 10-watt non-inductive resistor.

b. AC vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 hz to 330-kHz: input impedance 7.5 megohms.

c. DC Vacuum Tube Voltmeter (VTVM)

Voltage Range:	1.5 to 300 volts.
Input Impedance:	7.5 megohms.

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator

Output Voltage:	up to 8 volts.
Frequency Range:	20-kHz to 330-kHz.

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled, 0.45 mfd.; 330 V.A.C.	1723408
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C3	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized Paper, .047 mfd.;	849A437H04
C21	Metallized Paper, .047 mfd.;	849A437H04
C51	Dur-Mica, 1500 pf.; 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable, 5.5-18 pf.	879A834H01
C54	Metallized Paper, .1 mfd.; 200 V.D.C.	187A624H01
C55	Variable, 5.5-18 pf.	762A736H01
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized Paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf.; 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf.; 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C66	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd.; 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C70	3 pf.	861A846H03
C71	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C72	Dur-Mica, 300 pf. 500 V.D.C.	187A584H09
C73	Variable, 5.5-18 pt.	879A834H01
C74	3 pf.	861A846H03
C75	3 pf.	861A846H03
C76	3 pf.	861A846H03
C101	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C102	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C103 & C104	(30-50 KC) – Extended foil, 0.47 mfd.; 400 V.D.C.	188A293H01
C103 & C104	(50.5-75 KC) – Extended foil, 0.22 mfd.; 400 V.D.C.	188A293H02
C103 & C104	(75.5-100 KC) – Extended foil, 0.15 mfd.; 400 V.D.C.	188A293H03
C103 & C104	(100.5 - 150 KC) – Extended foil, 0.10 mfd.; 400 V.D.C.	188A293H04
C103 & C104	(150.5 - 300 KC) – Extended foil, 0.047 mfd.; 400 V.D.C.	188A293H05
	DIODES – GENERAL PURPOSE	
D11	1N645A	837A692H03
D12	1N645A	837A692H03
D13	1N4822	188A342H11
D14	1N4822	188A342H11

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
D15	1N4882	188A342H11
D16	1N4822	188A342H11
D21	1N645A	837A692H03
D22	1N4822	188A342H11
D23	1N4822	188A342H11
D24	1N4822	188A342H11
D25	1N4822	188A342H11
D51	1N628; 125 V., 30 MA.	184A885H12
D52	1N628; 125 V., 30 MA.	184A885H12
D55	1N457A; 60 V., 200 MA.	184A885H07
D58	1N628; 125 V., 30 MA.	184A885H12
D101	1N538; 200 V., 750 MA.	407C703H03
D102, D104	1N91; 100 V., 150 MA. (Germanium Version used with 2N1908)	182A881H04
D103	1N538; 200 V., 750 MA.	407C703H03
D102, D104	1N4818 (Silicon Version used with 2N3792	182A881H04
	DIODES – ZENER	
Z1	1N2828B; 45 V. ±5%; 50 W.	184A854H06
Z2	1N3009A; 130 V. ±10%; 10 W.	184A617H12
Z11	1N957B	186A797H06
Z12	1N3688A	862A288H01
Z13	1N3588A	862A288H01
Z14	1N3686B	185A212H06
Z21	1N957B	186A797H06
Z22	1N3688A	862A288H01
Z23	1N3688A	862A288H01
Z24	1N3686B	185A212H06
Z54	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
Z105	1N2999A; 56 V. ±10%; 10 W.	184A617H13
Z106	1N2999A; 56 V. ±10%; 10 W.	184A617H13
	RESISTORS	
R1	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R2	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R3	26.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H44
R3	500 ohms ±5%; 40 W. (For 125 V Supply)	1268047
R4	100 ohms ±10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
R11	4.7k ±2%; ½ W. Metal Glaze	629A531H48
R12	12K ±2%; ½ W. Metal Glaze	629A531H58
R13	10K ±2%; ½ W. Metal Glaze	629H531H56

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R14	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R15	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R16	47K ±2%; ½ W. Metal Glaze (For 125 Vdc)	629A531H72
R17	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R21	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R22	12K ±2%; ½ W. Metal Glaze	629A531H58
R23	10K ±2%; ½ W. Metal Glaze	629A531H56
R24	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R25	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R26	15K ±2%; ½ W. Metal Glaze (For 48 Vdc)	629A531H60
R27	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R51	10K ±5%; ½ W. Composition	184A763H51
R52	10K ±5%; ½ W. Composition	184A763H51
R53	10K ±5%; ½ W. Composition	184A763H51
R54	10K ±5%; ½ W. Composition	184A763H51
R55	100 ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K; ¼ W.	629A430H02
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms +5%; ½ W. Composition	184A859H06
R70	Potentiometer, 1K; ¼ W.	629A430H02
R71	4.7K ±5%; ½ W. Composition	184A763H43
R72	39K ±5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06
R74	180 ohms ±5%; ½ W. Composition	184A763H02
R75	100 ohms ±5%; ½ W. Composition	184A763H03
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R79	20K ±20%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ±20%; ¼ W.	629A430H09
R81	1K ±1%; 1½ W. Metal Film	849A819H48

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R82	5K Pot. ±20%; ½ W.	629A430H07
R83	10.2K ±1%; ½ W. Metal Film	848A820H46
R84	27 ohms ±5%; ½ W. Composition	187A290H11
R85	Thermistor 3D402 10 ohms	185A211H03
R86	750 ohms ±1%; ½ W. Metal Film	848A819H36
R87	10K ±5%; ½ W. Composition	184A763H51
R101	10 ohms ±5%; ½ W. Composition	187A280H01
R102	2.2K ±10%; 1 W. Composition	187A644H35
R103	2.7 ohms ±10%; ½ W. Composition	184A636H14
R104	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
R105	10 ohms ±5%; ½ W. Composition	187A290H01
R106	4.7K ±10%; 1 W. Composition	187A644H43
R107	2.7 ohms±10%; ½ W. Wire Wound	184A636H14
R108	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
	TRANSFORMERS	
T1	Driver Output Transformer	606B410G01
T2	Power Amp. Input Transformer	292B526G01
T3	Power Amp. Output Transformer	292B526G02
T4	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	606B537G01
T52	Driver Input Transformer	606B537G02
	*** TRANSISTORS**	
✪ Q1	2N6259 ‡	3503A41H01
✪ Q1	2N6259 with Heat Sink Assembly ‡	299B099G01
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q21	2N4356	849A441H02
Q22	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q55	2N697	184A638H18
Q56	2N2726	762A672H07
Q57	2N2726	762A672H07
✪ Q101, Q102	2N1908 (Use in Matched Pairs) (Germanium Version used with 1N91)	187A673H02
✪ Q101, Q102	2N3792 (Use in Matched Pairs) (Silicon Version used with 1N4818)	187A673H02
	MISCELLANEOUS	
Y1-Y2	Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing	408C743
FL101	Driver Filter	408C261 + (Req. Freq.)
FL102	Output Filter	541D214 + (Req. Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02
	Pilot Light Bulb - For 125 or 250 V. Supply (When supplied)	183A955H01
F1, F2	Fuse, 1.5 A (When supplied)	11D9195H26

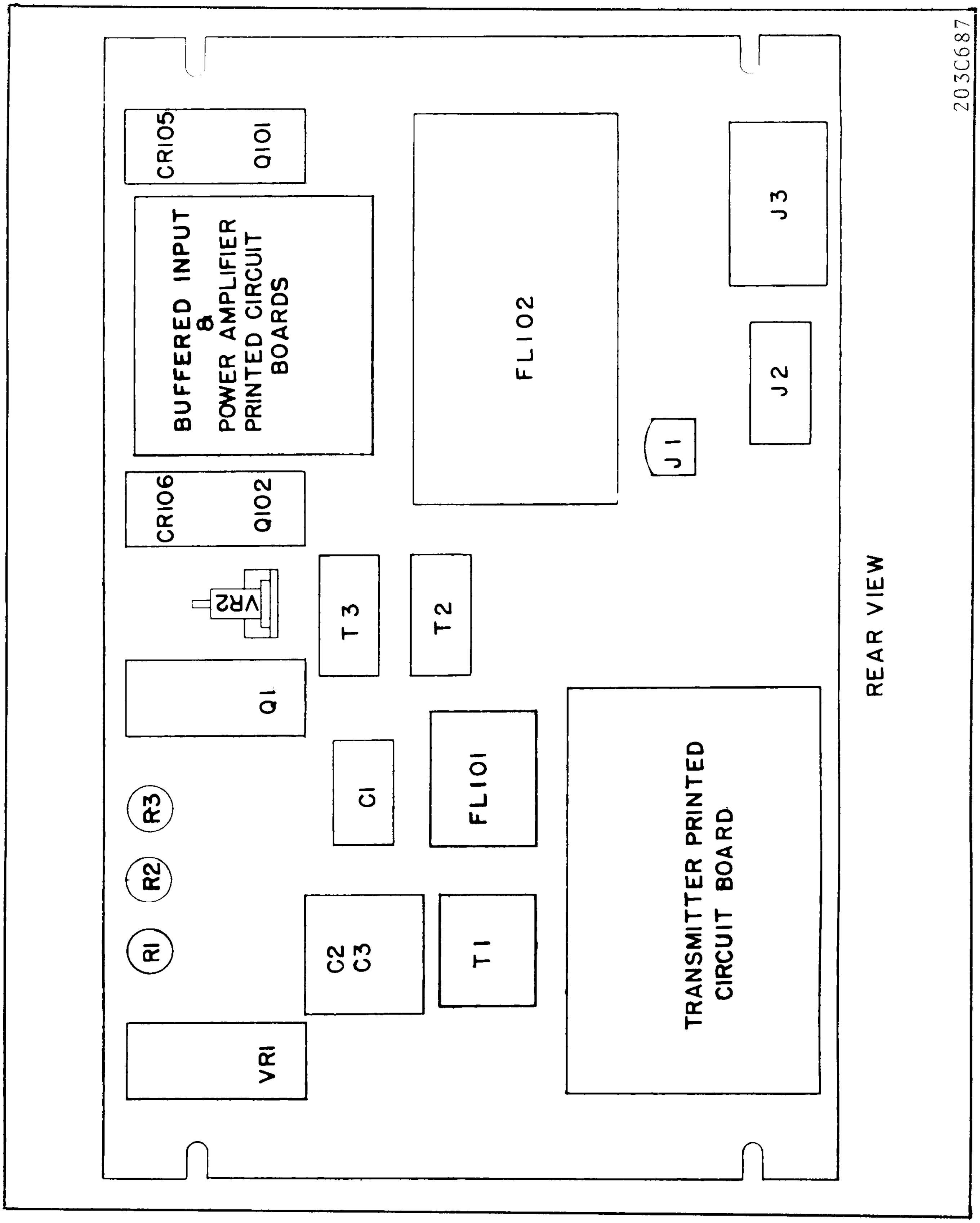

Fig. 2 Component Locations of the type TCF Transmitter Assembly

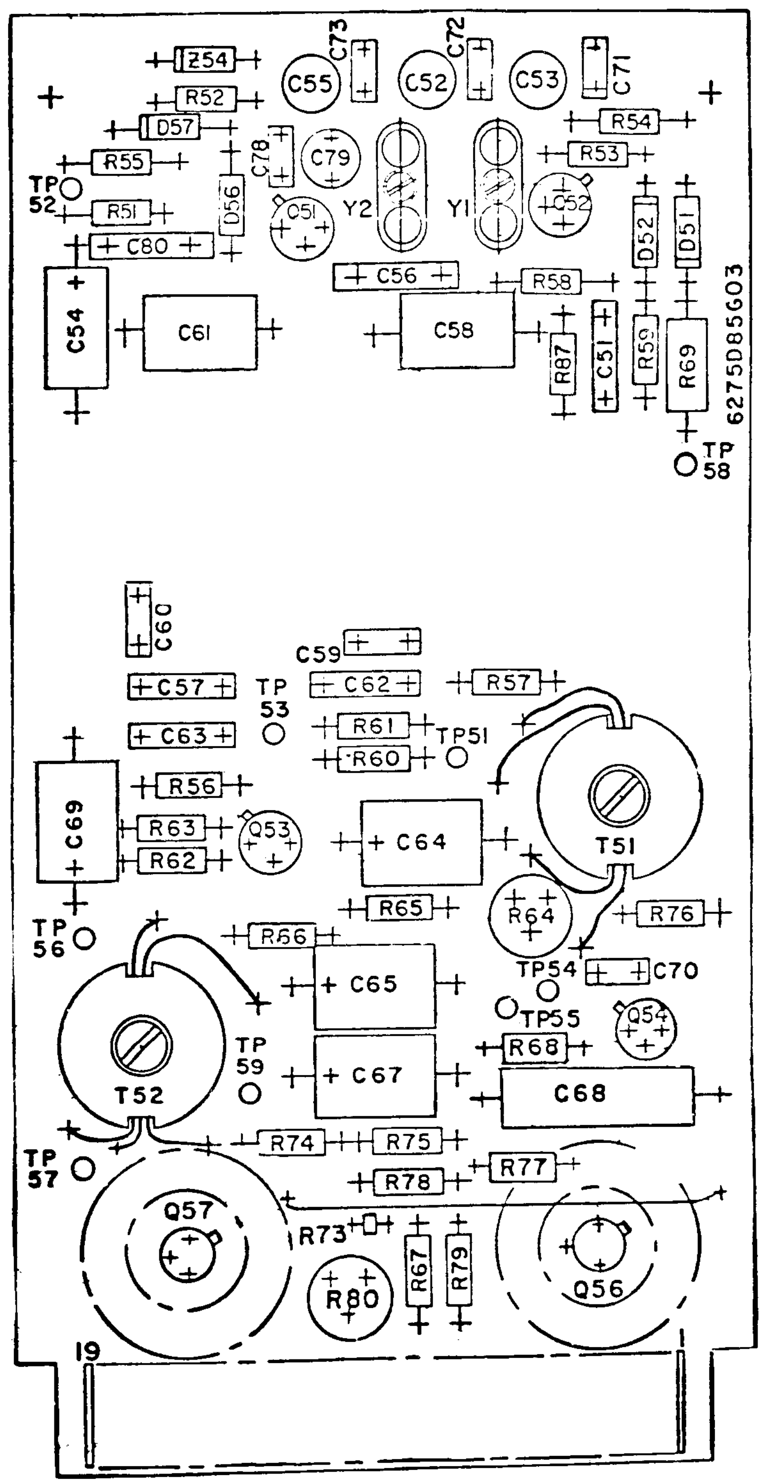

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Fig. 3. Component Locations of the Transmitter Printed Circuit Board.

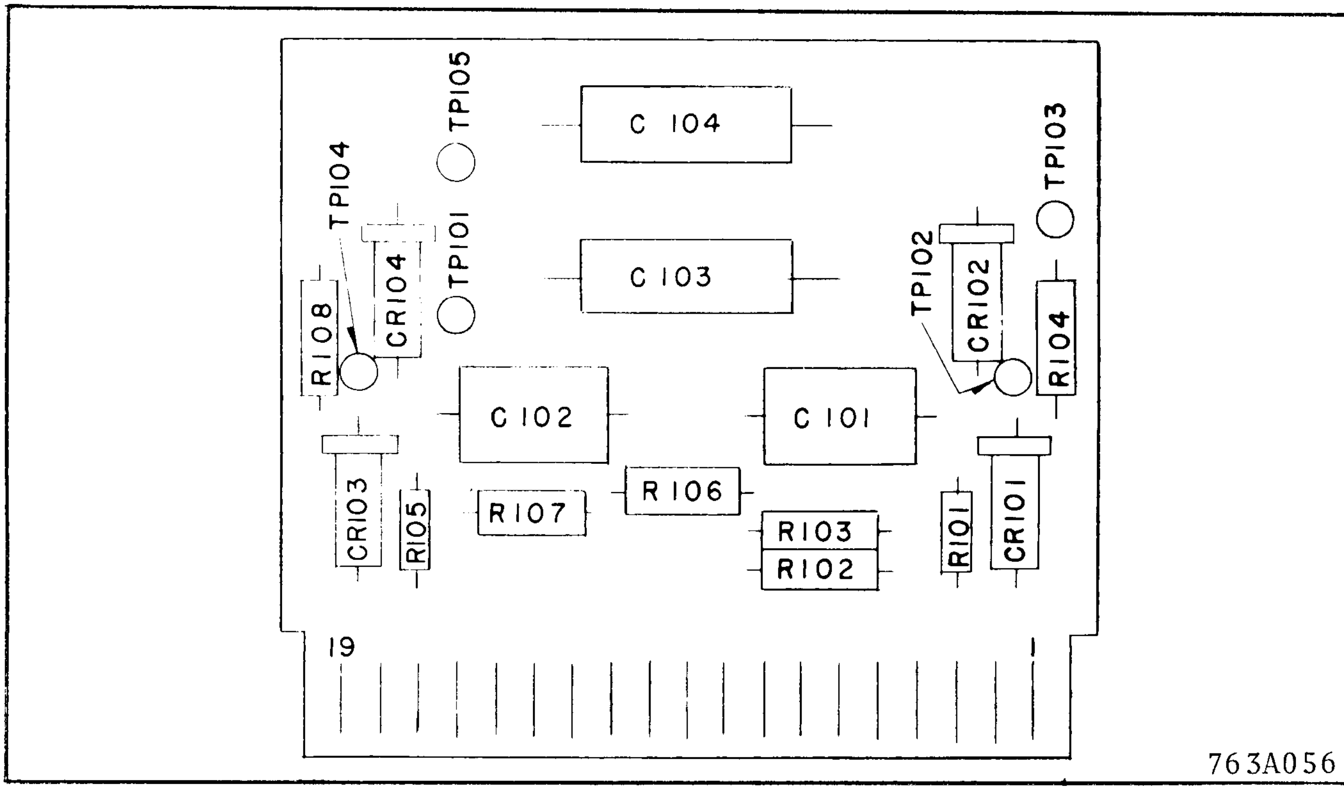


Fig. 4. Component Locations of the Power Amplifier Printed Circuit Board.

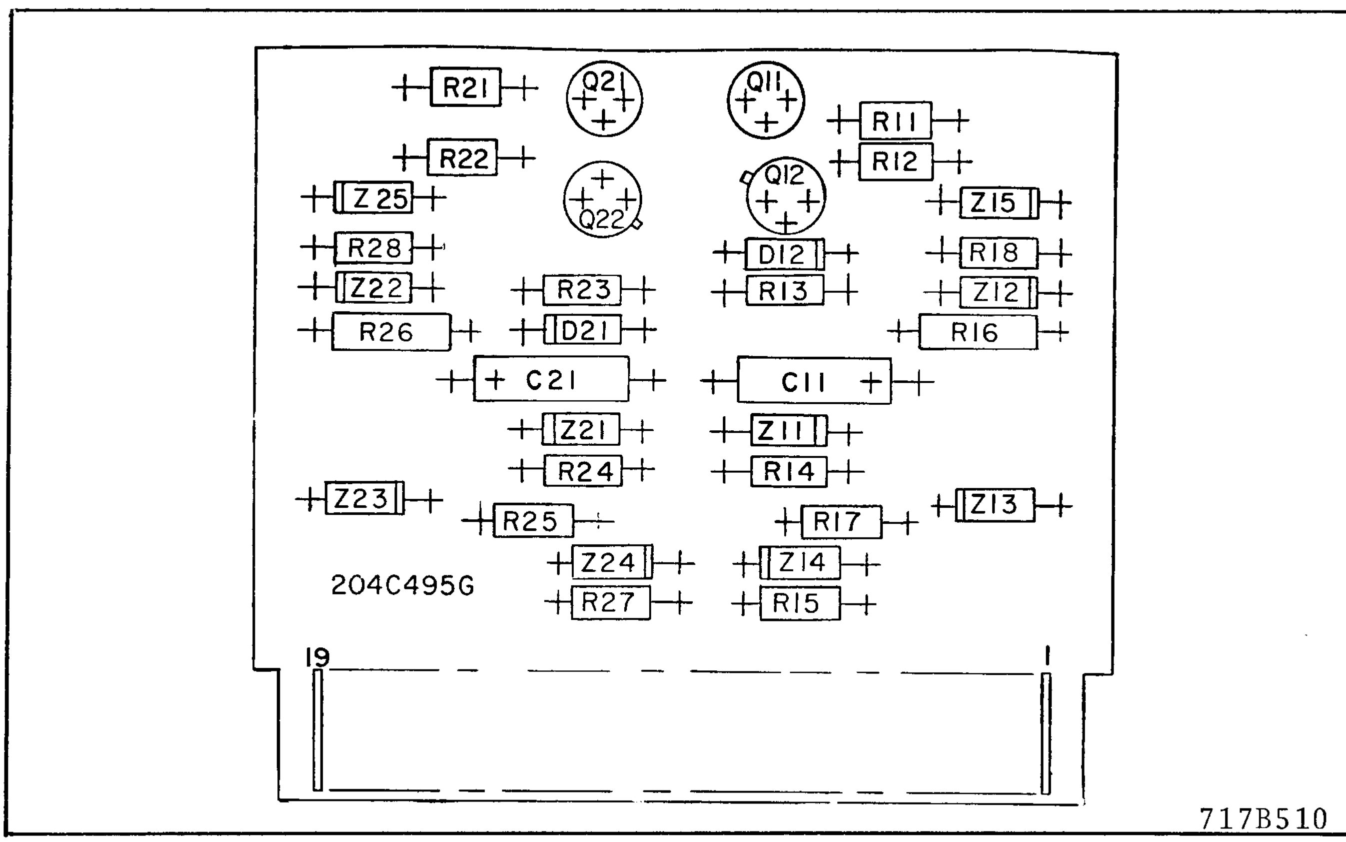


Fig. 5. Component Location of Buffer Keying Dircuit Board.

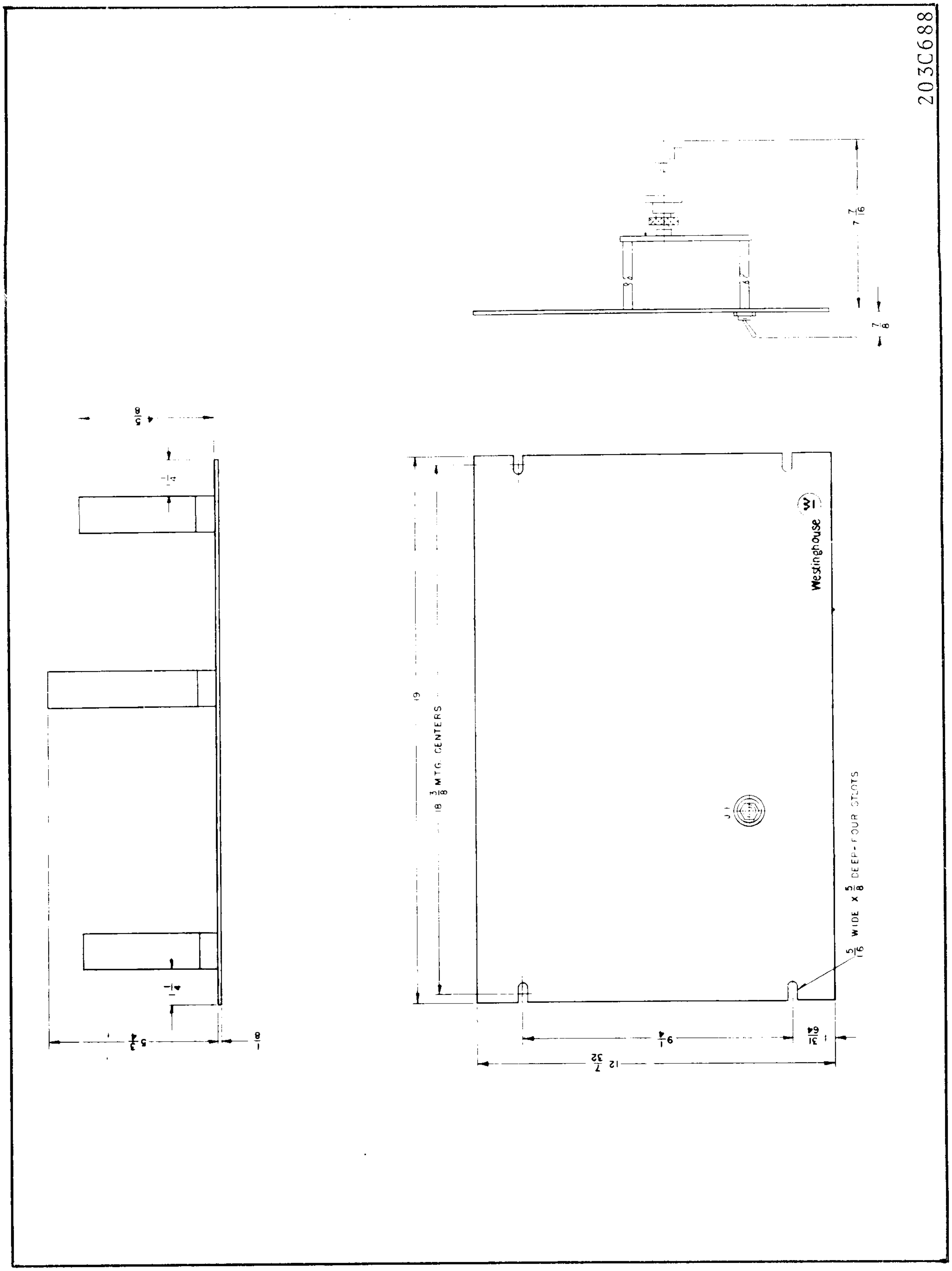
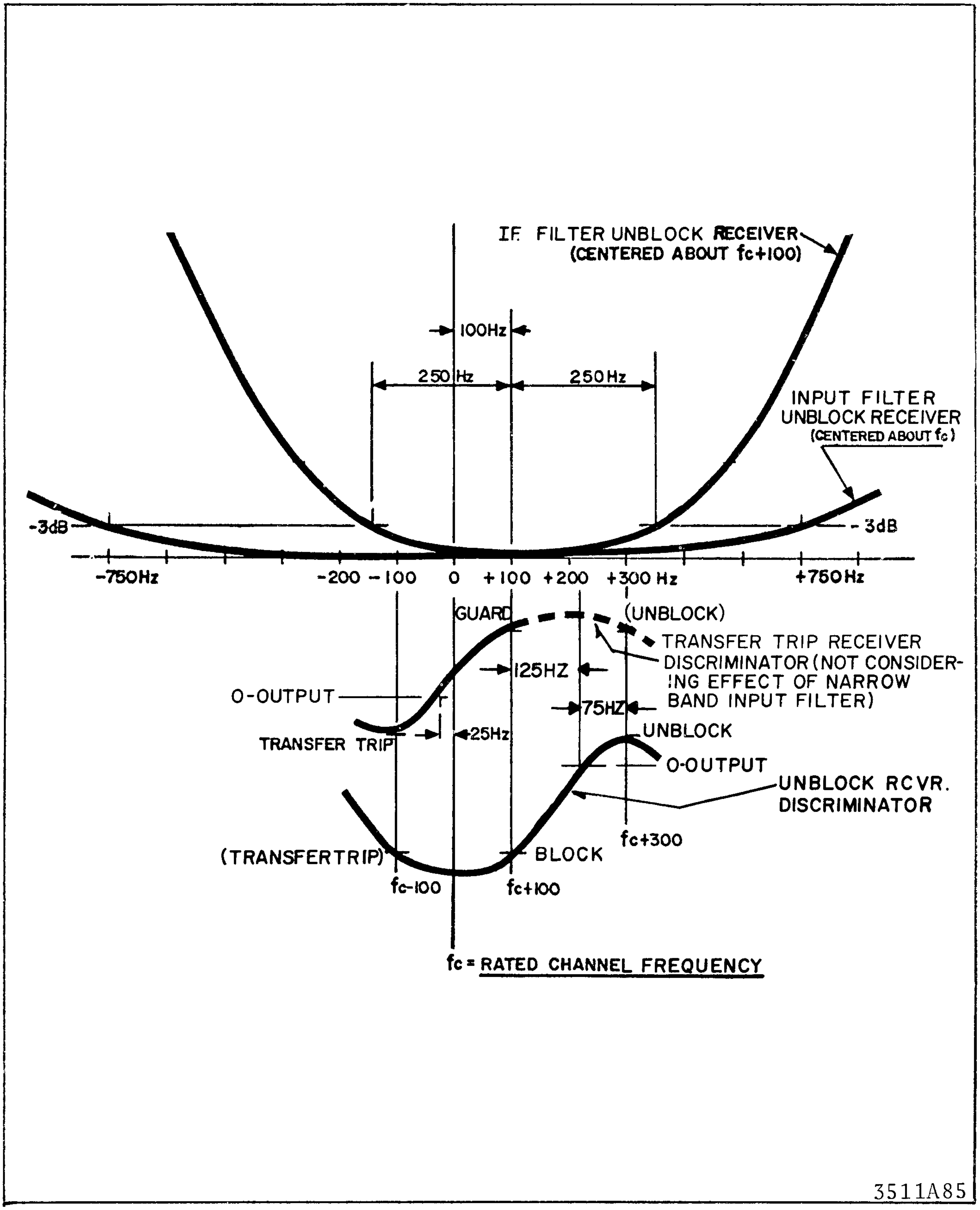


Fig. 6. Outline and Drilling Plan for the Type TCF Transmitter Assembly.



✪ *Fig. 7. Three Frequency Operation – Receiver Characteristics.*

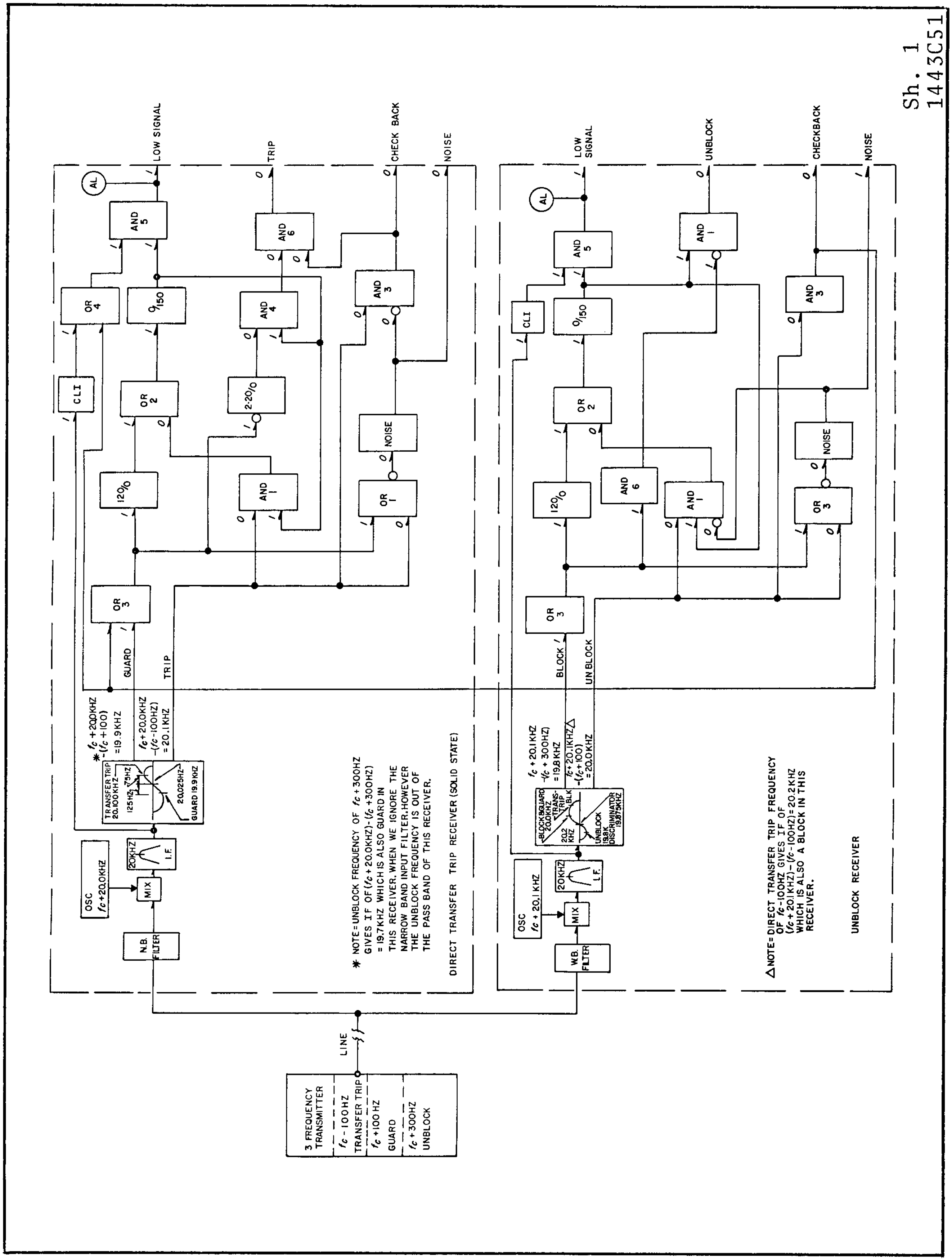
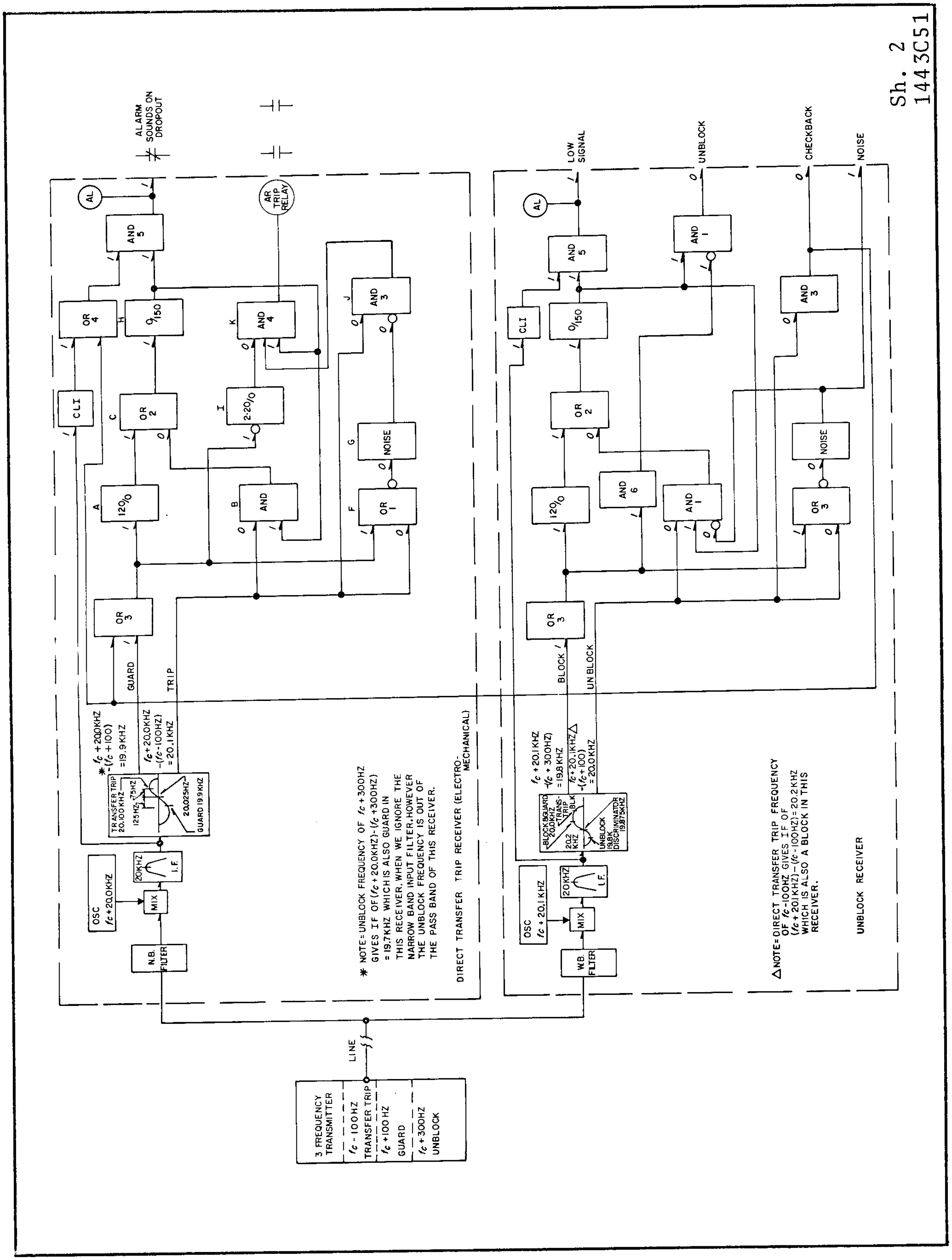


Fig. 8. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Solid-State Output) and Unblock Relaying.



✪ Fig. 9. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Contact Output) and Unblock Relaying.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

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