41-945.16

Attached is a copy of "Addendum To IL 41-945.16" for the TCF transmitter. This addendum sheet should be attached to your existing copy of IL 41-945.16 dated January 1976.

To keep our Instruction Leaflets updated, we will now issue an addendum to an existing IL and mail it using the regular means.

Addendums only will be issued to cover the following conditions:

1. An existing error in an IL should be corrected at once.
2. The IL is not entirely clear, added words will make it more understandable.

Relay-Instrument Division

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY — 10 WATT/1-3.25 WATT/10 WATT — WITH VOICE

This sheet notes changes which should be made in instruction leaflet I.L. 41-945.16 dated January 1976.

1. On Page 1, at bottom of page:

   delete reference to "Supersedes I.L. 41-945.12 dated July 1971."

2. On Page 1 at end of APPLICATION section,

   "Figure 7" should read "Figure 9".

3. On Page 1, right hand column, eleventh line

   "This logic is shown in Figure 12"

   should read -

   "This logic is shown in Figures 12 and 13"

4. On page 17:

   "Fig. 10. Receivers Logic Diagrams - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying"

   should read -

   "Fig. 12. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Solid-State Output) and Unblock Relaying"

5. On Page 18:

   "Fig. 13. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying"

   should read -

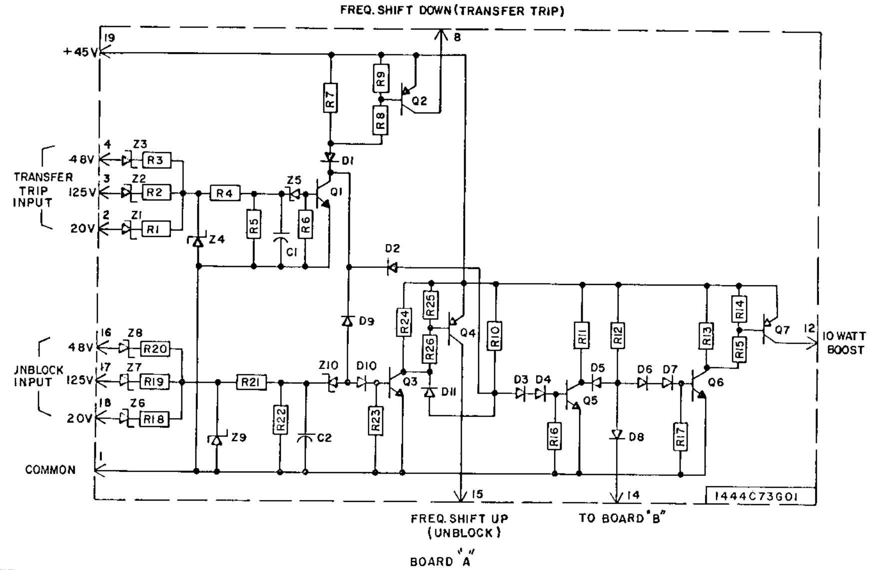
   "Fig. 13. Receiver Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Contact Output) and Unblock Relaying"

6. Add to page 19

   "Fig. 10. Schematic Buffer Keying Circuit Board "A" "

   "Fig. 11. Schematic Buffer Keying Circuit Board "B" "

NOTE: Fig. 10 and 11 are shown on other side of this sheet.

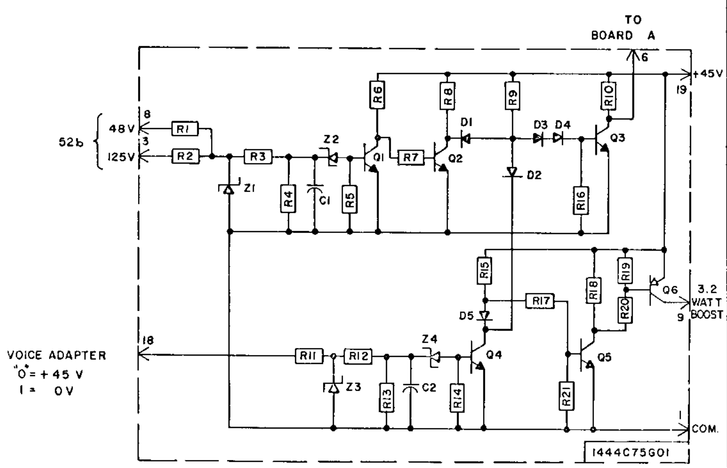


LOGIC BUFFER BD "A" (1444C73G01)

COMPONENT	STYLE	REQ.	REF.
TRANSISTORS			
Q1,Q3,Q5,Q6	184A638H19	4	(2N699)
Q2, Q4, Q7	849A441H02	3	(2N4356)
RESISTORS			
R4 – R21	629A531H36	2	1500 Ohms ½W + 2%
R1 – R18	629A531H38	2	1800 Ohms ½W + 2%
R5 – R22	629A531H51	2	6200 Ohms ½W + 2%
R6-R16-R17-R23	629A531H56	4	10K ½W + 2%
R7-R8-R11-R13-R15-R24-R26	629A531H58	7	12K ½W + 2%
R3 – R20	629A531H62	2	18K ½W +2%
R10 – R12	629A531H66	2	27K ½W +2%
R2 – R19	629A531H73	2	51K ½W +2%
R9–R14–R25	629A531H48	3	4.7K ½W +2%
CAPACITORS			
C1 – C2	849A437H04	2	.047 UF
DIODES			
D1,D2,D3,D4,D5,D6,D7,D8,D9,	837A692H03	11	IN645A
D10, D11			
DIO ZENER			
Z4 – Z9	185A212H06	2	IN3686B
Z5 – Z10	186A797H06	2	IN957B
Z1-Z2-Z3-Z6-Z7-Z8	629A369H01	6	1R200

775B312

Fig. 10 Buffer Keying Circuit Board "A"



LOGIC BUFFER BD. "B" (1444C75G01)

COMPONENT	STYLE	REQ	REF.
TRANSISTORS			
Q1 - Q2 - Q3 - Q4 - Q5	184A638H19	5	2N699
Q6	849A441H02	1	2N4356
RESISTORS			
R3 - R12	629A531H36	2	1500 Ohms ½W +2%
R4 – R13	629A531H51	2	6200 Ohms ½W +2%
R5-R14-R16-R21	629A531H57	4	11K ½W + 2%
R6-R8-R10-R15-R18-R20	629A531H58	6	12K ½W +2%
R1 – R11	629A531H62	2	18K ½W + 2%
R2	629A531H73	1	51K ½W + 2%
R7-R9-R17	629A531H66	3	27K ½W + 2%
R19	629A531H48	1	4.7K ½W + 2%
CAPACITORS			
C1 – C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5	837A692H03	5	IN645A
DIO ZENER			
Z1 - Z2 - Z3 - Z4	185A212H06	4	IN3686B

775B314

Fig. 11 Buffer Keying Circuit Board "B"

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/1-3.25 WATT/10 WATT — WITH VOICE

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 wideband 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" "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 a similar 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 an OR logic circuit). This logic is shown in Figure 12. 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.

The transmitter can also be amplitude modulated at 3.25 watts to provide a voice channel.

CONSTRUCTION

The 10 watt/1-3.25 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. 8. All of the circuitry that is suitable for printed circuit board mounting is on three 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 four printed circuit boards are shown on separate illustrations, Fig. 3, 4, 5, & 6.

External connections to the assembly are made through a 24-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

Supersedes I.L. 41-945.12, dated July 1971
New Information

EFFECTIVE January 1976

OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel center frequency, a mixer and buffer amplifier, a driver stage and a power amplifier, a driver stage and a power amplifier. The interstage filter is located between the driver and the power amplifier. The output filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 kHz to 300 kHz range cannot be forced to oscillate away from its natural frequency by as much as ± 100 hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel center frequency, or 2.03 MHz for 30 kHz center frequency. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter following mode. The emitter is coupled to the base through C57. With Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Capacitor C79 (in parallel with C78) is not effective until D59 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control for unblock is closed which places 45V. dc at terminal 12 of the printed circuit board. With D57 conducting, C79 and C78 are placed in parallel with C55 and C73. The adjustment of C79 will reduce the frequency of the Y2 circuit by 200 hz. Since Y2 is the lower of the two frequencies derived from Y1 and Y2, the difference frequency, which is ıe frequency transmitted, is now increased by 200 hz. Thus the frequency transmitted is now 200 hz above the guard frequency or 300 hz above the center frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 hz above its marked frequency. Capacitors C53 and C71 are not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control is closed, which places 45 V. dc at terminal 1 of the printed circuit board. With D51 conducting, C53 and C71 are effectively in parallel with C52 and C72. The adjustment of C53 will reduce the frequency by 200 hz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ± 10 Hz over a temperature range of − 20 to + 55° C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the keying control is closed, it increases the output power from 1 watt to 10 watts as well as changing the frequency from Guard to Transfer or Unblock Trip. This is effected by reducing the emitter resistance of buffer-amplifier transistor Q54. When the keying control is open, transistor Q55 receives no base current and is non-conducting. Emitter resistor R70 therefore is effectively open-circuited. The level of output power is adjusted to 1 watt by means of R64. When Q55 is made conductive by closing the keying control circuit, R70 is placed in parallel with R68 and the amount of emitter resistance unbypassed by C66 can be adjusted as required to obtain a 10-watt output level.

Note in the keying board logic there is that interlocking logic between the keying for "unblock" and the keying for "transfer trip". This logic permits the "transfer trip" keying to take preference over the "unblock" keying. That is even if we have "unlock" keying and then get "transfer trip" keying, th "transfer trip" will take immediate preference over the "unblock" keying. This is accomplished by the "transfer trip" keying causing transistor Q1 to conduct which in turn shunts out the keying voltage input to transistor Q3 through diode D9. Thus while Q1 becomes conducting and consequently Q2, effecting "transfer trip" keying, this conduction of Q1 also prevents Q3 from becoming conducting and prevents "unblocking" keying.

As is shown on the Internal Schematic, Fig. 1, the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the input level. In addition, network R67, R79, and potentiometer R80 are used in the bias circuit and are adjusted by means of R80 to limit the quiscent current in the driver stage common to 0.2 ma. This adjustment is made by unsoldering the lead going from pin 2 of the transmitter to terminal 2 of transformer T1 and inserting a d-c milliammeter (0-1.0 ma) between this pin 2 and terminal 2 of T1. The R80 is adjusted to produce 0.2 ma ± .05 in this circuit, after this, the milliameter is removed and the lead replaced.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of this signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors. Zener diodes Z105 and Z106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the output filter FL102. The output filter includes two trap circuits (L102, CB and L103, CC) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor CD approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line turner and coaxial cable. Auto-transformer T4 matches the filter impedance to coaxial cable of 50, 60, or 70 ohms.

The series resonant circuit composed of L105, and CE is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reserve impedance that is free of possible "across-the-line" resonances.

The power supply is a series-type transistorized d-c voltage regulator which has a very low stand-by current drain when there is no output current demand. The Zener diode Z1 hols a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The Zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 by pass r.f. or transient voltages to ground, thus preventing damage to the transistor circuit.

When keyed for voice by the voice adapter, transistor Q55 is keyed into class A operation so that its conduction can be modulated by the voice input from the voice adapter. Potentiometer R82 is adjusted so that the nominal output of carrier is 3.25 watts (14 volts across 60 ohms). The voice input modulates the carrier through this transistor by varying the amount of conduction of Q55 so that the output power of carrier varies with the voice amplitude following the voice frequency components. Since with Q55 completely non-conducting, R64 has been set to produce a 1 watt output, maximum modulation on the side to shut off Q55 will not result in an output level of less than 1 watt carrier at any time. Also since the output level has been set at 10 watts with Q55 completely conducting by the adjustment of R70, the maximum modulation on the side of turn on of Q55 will not result in a carrier output level of greater than 10 watts at any time. Thus the modulation for voice will not result in the output carrier level dropping below 1 watt and endangering the guard frequency for relaying purposes.

The buffer keying board in addition to providing proper buffering, also contains logic for the proper keying of both frequency and output level in regards to protective relaying operation, voice adapter operation, and 52b contact operation.

It should be remembered that protective relaying operation has first priorty. If the protective relay operates and puts a voltage input into any of the three input points labeled carrier auxiliary keying, the transmitter will both frequency shift to trip frequency and full 10 watts output whether voice is called for or not.

The operation of the 52b contact will remove the 10 watt keying output and permit the voice adapter to key to 3.2 watts output for AM voice modulation. This allows voice modulation on the trip frequency after the 52b contact has operated.

CHARACTERISTICS

Frequency Range	30-300 kHz
Output	1 watt guard — 10 watts trip — (both transfer and unblock) — 3.2 watts voice (into 50 to 70 ohm resistive load)
Frequency Stability	±10 Hz from −20°C to +55C.
Frequency spacing	Two-way channel, — See Voice Adapter Instruction Leaflet.
Harmonics	Down 55 db (min.) from output level.
Input voltage	48 or 125 v.d.c.

Supply voltage variation	42-56v. for nom. 48v. supply. 105-140v. for nom. 125v. supply.	
Battery drain	0.5 a. guard 1.15 a. trip	48 v.d.c.
	0.5 a. guard 0.9 a. trip	125 v.d.c
Keying circuit current	4 ma.	
Temperature range	−20 to +60°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 car ier 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 60°C.

ADJUSTMENTS

The TCF 10W/1-3.2W/10W 3 Frequency transmitter is shipped with the power output controls R64, R82 and R70, set for outputs of 1 watt, 3.2 watts and 10 watts into a 60 ohm load. If it is desired to check the 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 3 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.

Then change to Trip frequency by connecting together terminals 7 and 12 of the transmitter connector 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 and remove the jumper used to key the transmitter to the 10 watt level. Key for voice by opening any connection terminal to 10 of J3. Turn the power back on. Adjust R82 for a 3.2 watt output across the load resistor (14V across 60 ohms). Open the power switch, reconnect connection to terminal 10 of J3, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

VOLTAGE FOR

T106 TAP	1 WATT OUTPUT	3.2 WATTS OUTPUT	10 WATTS OUTPUT
50	7.1	12.7	22.4
60	7.8	14	24.5
70	8.4	15	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 the 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 and avoids some error from the effect of 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, the Transfer Trip Adjustment with C53, and the unblock frequency with C79.

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 d-c 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 d-c 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 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	Voltage at 3.2 Watts Output (For Voice)
TP52	20	20	20
TP53	5.4	5.4	5.4
TP54	3.4	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	Voltage at 3.2 watts Output (For Voice)
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-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	14

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. Se 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. Se 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. Mimimum 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 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

TRANSMITTER—(6275D85G09)

Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q51-Q52-Q53-Q55	184A638H18	4	2N697
Q54	184A638H19	1	2N699
Q56-Q57	762A672H07	2	2N2726/2N3712
RESISTORS			
R51 to R54-R59-R62-R87	184A763H51	7	10K 1/2W ±5%
R56-R57	184A763H40	2	36K 1/2W ±5%
R60-R72	184A763H45	2	5.6K 1/2W ±5%
R61	184A763H55	1	15K 1/2W ±5%
R63	184A763H27	1	1K 1/2W ±5%
R65	184A763H33	1	1.8K 1/2W ±5%
R66	184A763H49	1	8.2K 1/2W ±5%
R67	629A531H58	1	12K 1/2W ±2%
R68	184A763H15	1	330 Ohms 1/2W ±5%
R69	184A859H06	1	800 Ohms 3W ±5%
R71	848A820H27	1	6.49K 1/2W ±1%
R74	629A531H03	1	62 Ohms 1/2W ±2%
R75	187A290H21	1	68+ 1/2W ±5%
R76	184A763H34	2	2K 1/2W ±5%
R77-R78	187A290H01	2	10+ 1/2W ±5%
R79	629A531H63	1	20K 1/2W ±2%
R81	848A819H48	1	1K 1/2W ±1%
R83	848A820H45	1	10K 1/2W ±1%
R84	187A290H01	1	271 1/2W ±5%
R86	848A819H36	1	750 Ohms 1/2W ±1%
R55-R58	184A763H03	2	100 Ohms 1/2W ±5%
CAPACITORS			
C51-C80	762A757H03	2	(1500 MMF)
C54	187A624H01	1	(.1 MFD)
C56-C57	187A584H01	2	2000 MMF
C58-C61-C64-C65-C66-C67-C69	187A624H02	7	.25 MFD
C59-C60	762A757H01	2	100 MMF
C62	762A757H04	1	4700 MMF
C63	762A757H02	1	1000 MMF
C68-C75	187A624H03	2	.5 MFD
C74	187A624H04	1	1 MFD
C70	187A584H09	1	300 MMF
C71-C72-C73-C78	861A846H03	4	3 MMF
C76	764A278H10	1	.01 MFD
C77	188A669H01	1	.47 MFD
DIODES			
D51-D52-D56-D57-D58	184A855H12	5	(IN628)
D55	184A855H07	1	IN457A
DIO ZENER			
Z54	185A212H06	1	IN3686B
TRANSFORMER			
T51	606B537G01	1	
T52	606B537G02	1	
THERMISTOR			
R73	185A211H06	1	(3D202)
R85	185A211H03	1	3D402
POTENTIOMETER			
R64-R70	619A430H02	2	1K 1/4W ±20%
R80	629A430H09	1	25K 1/4W ±20%
R82	629A430H07	1	5K 1/4W ±20%
TRIMMER			
C52-C53-C55-C79	879A834H01	4	5.5 18PF

LOGIC BUFFER BD. "B" (1444C75G01)

Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q1-Q2-Q3-Q4-Q5	184A638H19	5	2N699
Q6	849A441H02	1	2N4356
RESISTORS			
R3-R12	629A531H36	2	1500 Ohms 1/2W ±2%
R4-R13	629A531H51	2	6200 Ohms 1/2W ±2%
R5-R14-R16-R21	629A531H57	4	11K 1/2W ±2%
R6-R8-R10-R15-R18-R20	629A531H58	6	12K 1/2W ±2%
R1-R11	629A531H62	2	18K 1/2W ±2%
R2	629A531H73	1	51K 1/2W ±2%
R7-R9-R17	629A531H66	3	27K 1/2W ±2%
R19	629A531H48	1	4.7K 1/2W ±2%
CAPACITORS			
C1-C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5	837A692H03	5	IN645A
DIO ZENER			
Z1-Z2-Z3-Z4	185A212H06	4	IN3686B

ELECTRICAL PARTS LIST (Cont'd.)

POWER AMP (606B530)

Components	*Style*	*Req.*	*Ref.*
RESISTORS			
R101-R105	187A290H01	2	10 Ohms 1/2W ±5%
R102	187A644H35	1	2.2K 1W ±10%
R103-R107	184A636H14	2	2.7Ω 1/2W ±10%
R104-R108	184A636H18	2	0.27Ω 1W ±10%
R106	187A644H43	1	4.7K 1W ±10%
CAPACITORS			
C101-C102	187A624H02	2	.25 MFD, 200V DC
C103-C104	S. No. PER S.O.	2	
DIODES			
D102-D104		2	See Note Δ
D101-D103	188A342H06	2	IN4818

LOGIC BUFFER BD. "A" (1444C73G01)

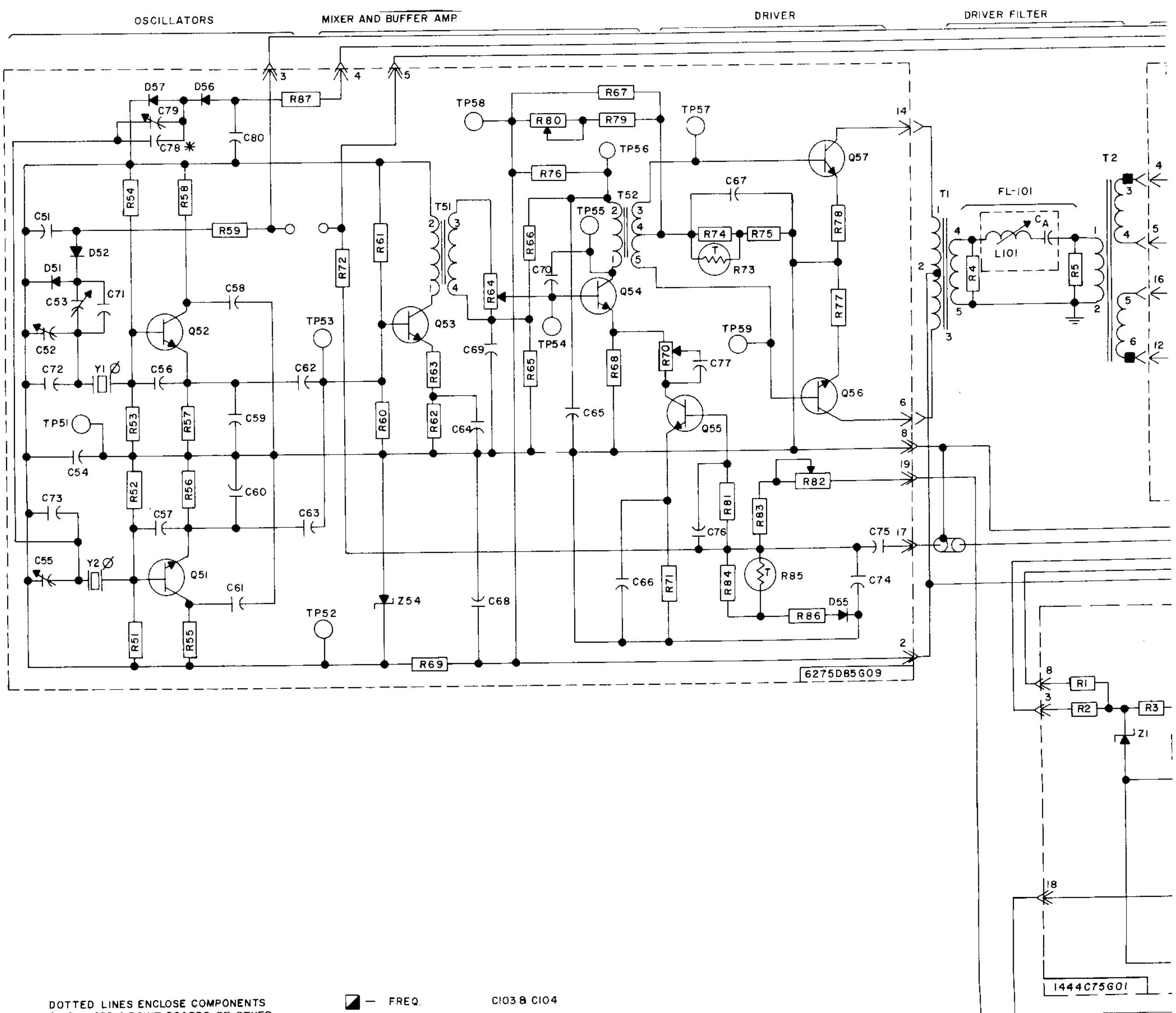
Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q1-Q3-Q5-Q6	184A638H19	4	(2N699)
Q2-Q4-Q7	849A441H02	3	(2N4356)
RESISTORS			
R4-R21	629A531H36	2	1500 Ohms 1/2W ±2%
R1-R18	629A531H38	2	1800 Ohms 1/2W ±2%
R5-R22	629A531H51	2	6200 Ohms 1/2W ±2%
R6-R16-R17-R23	629A531H56	4	10K 1/2W ±2%
R7-R8-R11-R13-R15-R24-R26	629A531H58	7	12K 1/2W ±2%
R3-R20	629A531H62	2	18K 1/2W ±2%
R10-R12	629A531H66	2	27K 1/2W ∓2%
R2-R19	629A531H73	2	51K 1/2W ±2%
R9-R14-R25	629A531H48	3	4.7K 1/2W ±2%
CAPACITORS			
C1-C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5-D6-D7-D8-D9 D10-D11	837A692H03	11	IN645A
DIO ZENER			
Z4-Z9	185A212H06	2	IN3686B
Z5-Z10	186A797H06	2	IN957B
Z1-Z2-Z3-Z6-Z7-Z8	629A369H01	6	IR200

OUTPUT FILTER

Component	*Style*	*Req.*	*Ref.*
FL-102	S. No. PER S.O.	1	541D214 200KHz
FL-102	S. No. PER S.O.	1	5481D10 200 to 300KHz

OTHER

Component	*Style*	*Req.*	*Ref.*
RESISTORS			
R1-R2	04D1299H44	2	26.5 OHMS
R3	04D1299H44	1	26.5 Ohms 48V DC
R3	1268047	1	500 Ohms 125V DC
R4	187A644H03	1	100 Ohms
R5	187A641H27	1	1K 10% 1/2W
R6	188A317H01	1	3000 Ohms 5W ±5%
CAPACITORS			
C1	1723408	1	(0.45 MFD)
C2-C3	1877962	2	(0.5 MFD)
DIODE			
D1	188A342H06	1	(IN4818)
DIODE-ZENER			
Z3	584C434H08	1	(IN1789)
Z1	184A854H06	1	(IN2828B)
Z2	184A617H12	1	(IN3009A)
TRANSISTOR			
Q1	3503A41H01	1	(2N6259)
TRANSFORMERS			
T1	606B410G01	1	
T2	292B526G01	1	
T3	292B526G02	1	
FILTER			
FL-101	S. No. PER S.O.	1	408C261 30-200KC
FL-101	S. No. PER S.O.	1	202C074 200 to 300KC
TELEPHONE JACK	187A606H01	1	J1



DOTTED LINES ENCLOSE COMPONENTS ON PRINTED CIRCUIT BOARDS OR OTHER SUB-ASSEMBLIES (EXCEPT AS NOTED)

J3

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24

(AS VIEWED FROM REAR SIDE OF PANEL)

◪ – FREQ.

FREQ.	C103 & C104
30-50KHZ	0.47MFD
50.5-75KHZ	0.22MFD
75.5-100KHZ	0.15MFD
100.5-150KHZ	0.10MFD
150.5-300KHZ	0.047MFD

◆ – MOUNTED ON LARGE HEAT SINKS

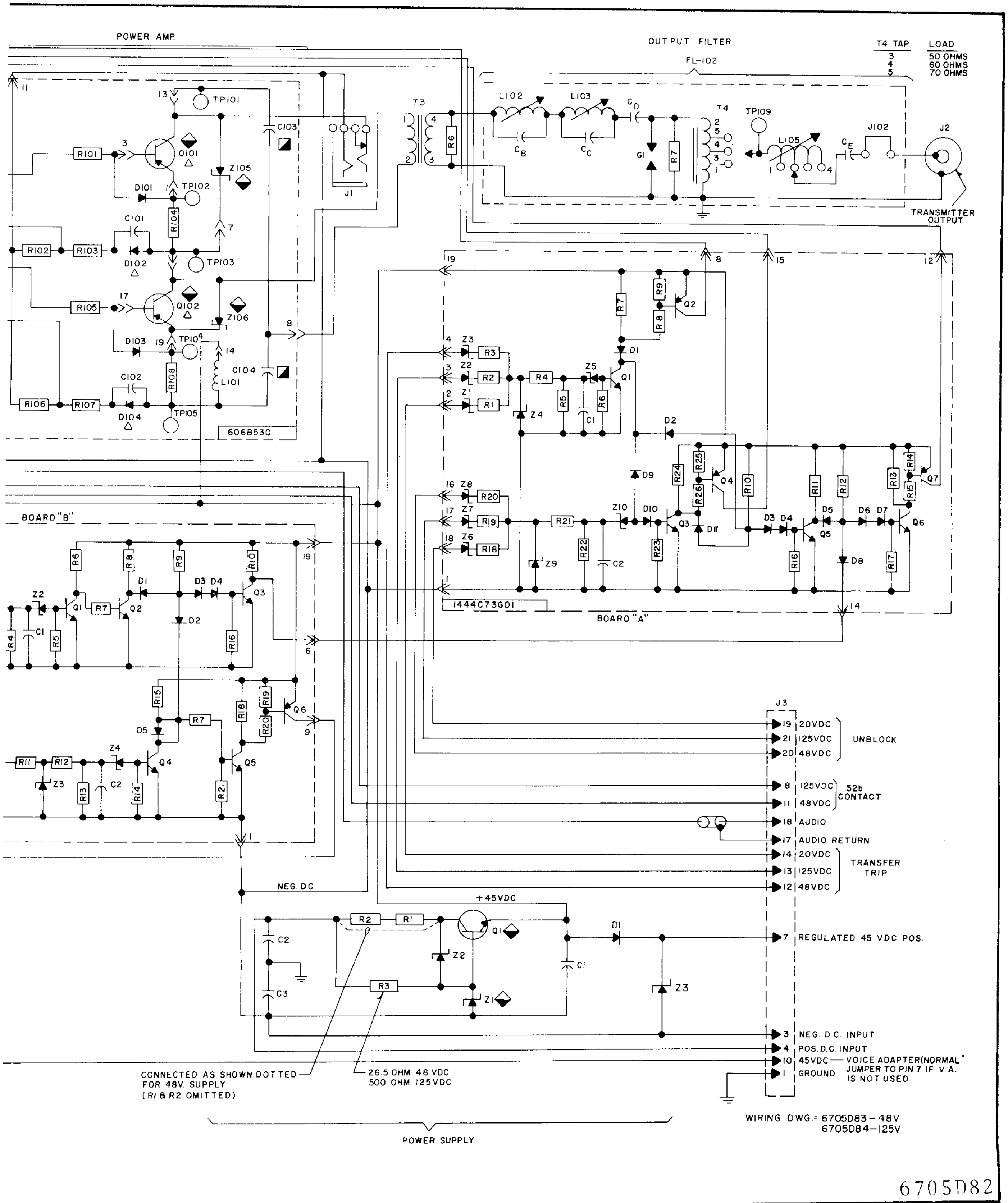
∅ – MATCHED PAIR
Y1 – 2.03 TO 2.30MHZ
Y2 – 2.00MHZ

✱ – C78 SUPPLIED IF REQUIRED IN TEST

△ – FOR SILICON VERSION USE 2N3792 S# 187A673H16, WITH DIODES D102 & D104, IN4818 S# 188A342H06 ON BD. STYLES 606B530G08 TO G12.

ALL CAPACITORS ARE IN MFD. EXCEPT AS NOTED.

Fig. 1. Internal Schematic of the Type TCF 3-Frequei



ıcy, 10 Watt/1 Watt/10 Watt Transmitter.

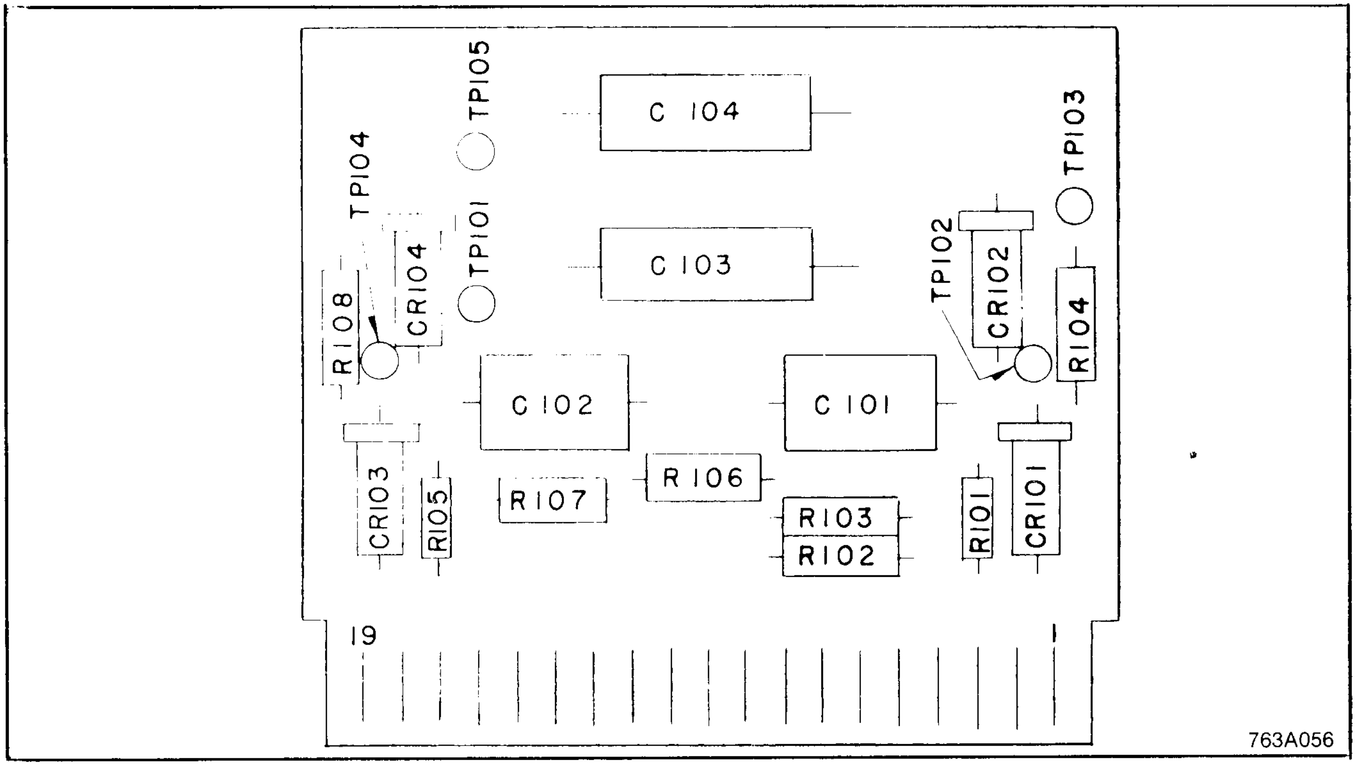


Fig. 4. Component Locations of the Power Amplifier Printed Circuit Board

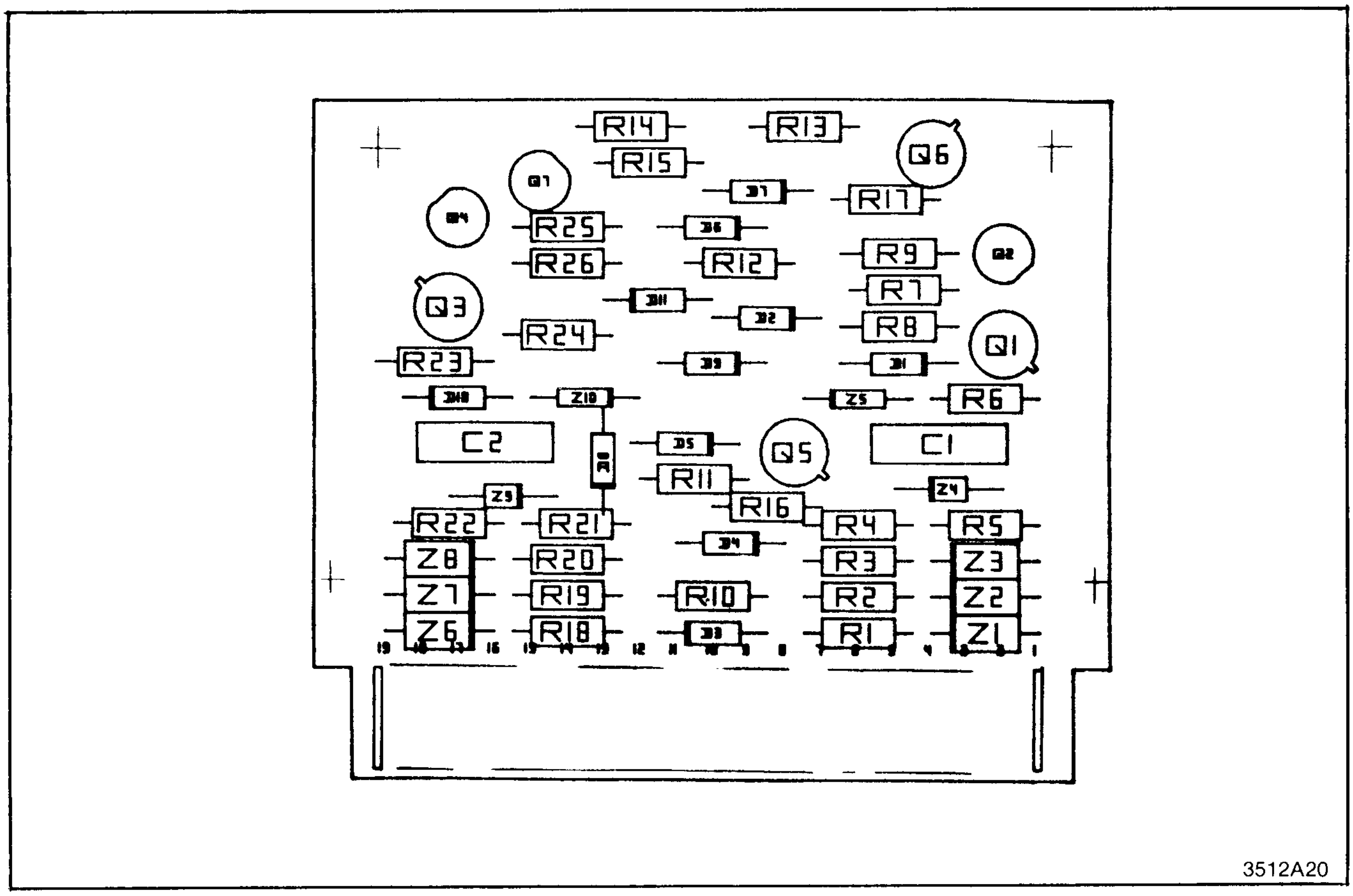


Fig. 5. Component Location of Buffer Keying Circuit Board A

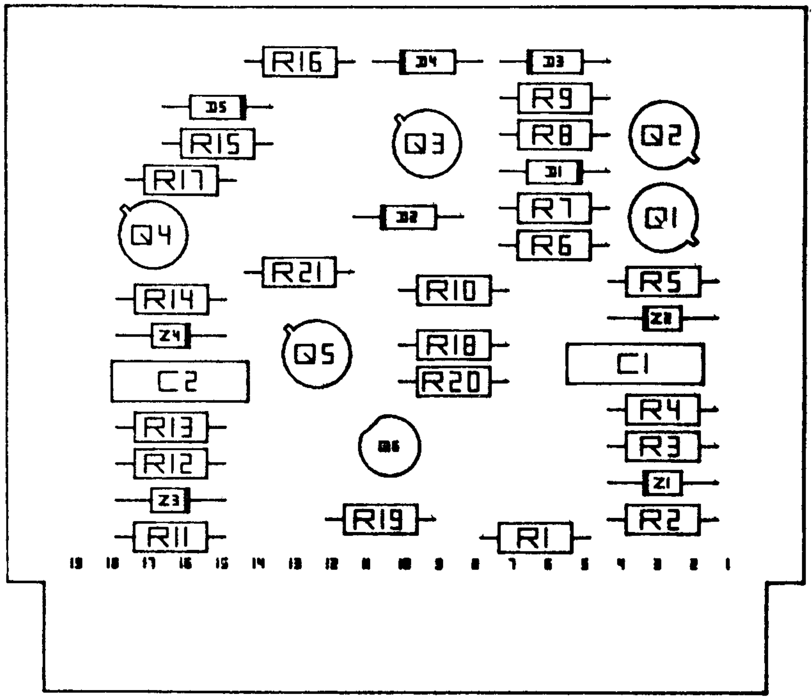
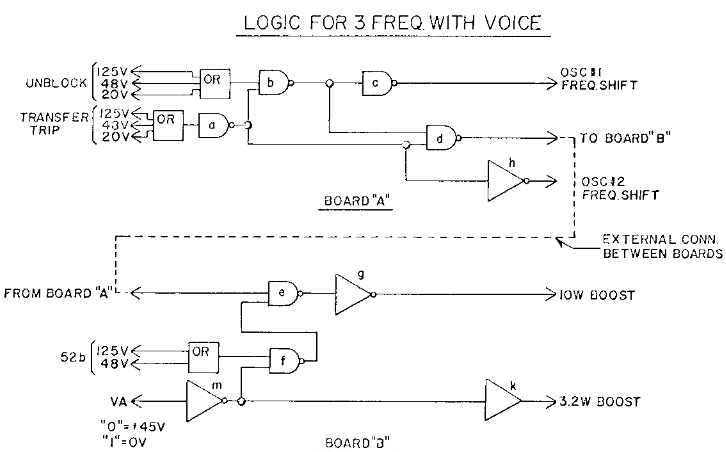


Fig. 6. Component Location of Buffer Keying Circuit Board B



TRUTH TABLE-3 FREQ. WITH VOICE

INPUT KEYING				OUTPUTS				
UN	TT	52b	VA	TT FREQ. SHIFT	UN FREQ. SHIFT	3.2W BOOST	10W BOOST	
0	0	0	0	0	0	0	0	GUARD @ 1W
1	0	0	0	0	1	0	1	UNBLK. @ 10W
1	1	0	0	1	0	0	1	T.T. @ 10W
1	0	1	0	0	1	0	1	UNBLK @ 10W
1	0	0	1	0	1	0	1	UNBLK. @ 10W
1	1	1	0	1	0	0	1	TT @ 10W
1	0	1	1	0	1	1	0	UNBLK @ 3.2W
1	1	0	1	1	0	0	1	TT @ 10W
1	1	1	1	1	0	1	0	TT @ 3.2W
0	1	0	0	1	0	0	1	TT @ 10W
0	1	1	0	1	0	0	1	TT @ 10W
0	1	0	1	1	0	0	1	TT @ 10W
0	1	1	1	1	0	1	0	TT @ 3.2W
0	0	1 *	0	0 *	1	0	1	UNBLK @ 10W
0	0	1 *	1	0 *	1	1	0	UNBLK @ 3.2W
0	0	0	1	0	0	1	0	GUARD @ 3.2W

* = STU RELAY AFTER 180MS OPERATION OF 52b WILL KEY TO UNBLOCK. IN THIS CASE, THE UNBLOCK KEYING IS NOT DONE BY THE LOGIC REPRESENTED BY THESE LOGIC BOARDS.

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Fig. 7. Logic Drawing for 3 Frequency with Voice.

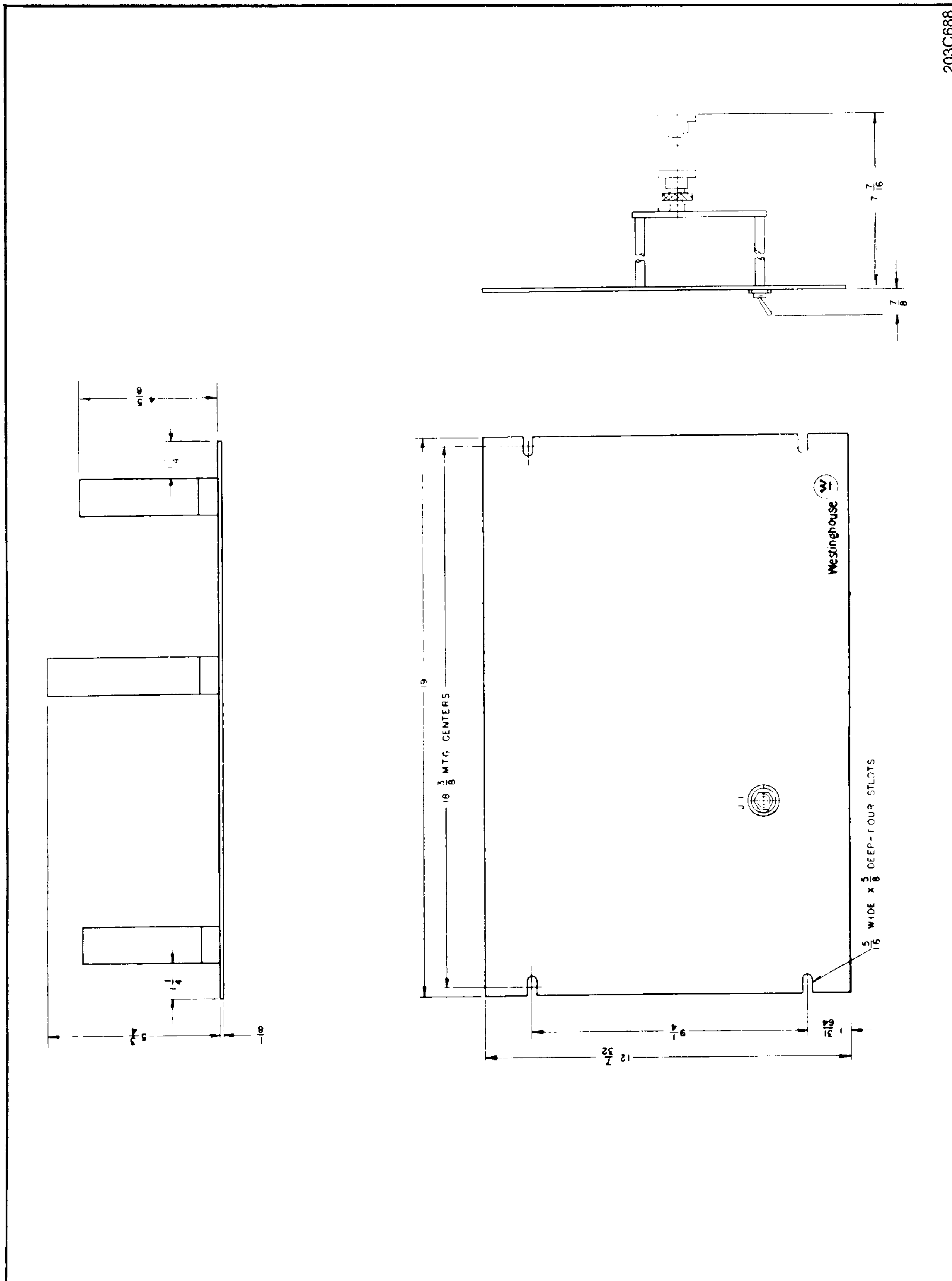


Fig. 8. Outline and Drilling Plan for the Type TCF Transmitter Assembly

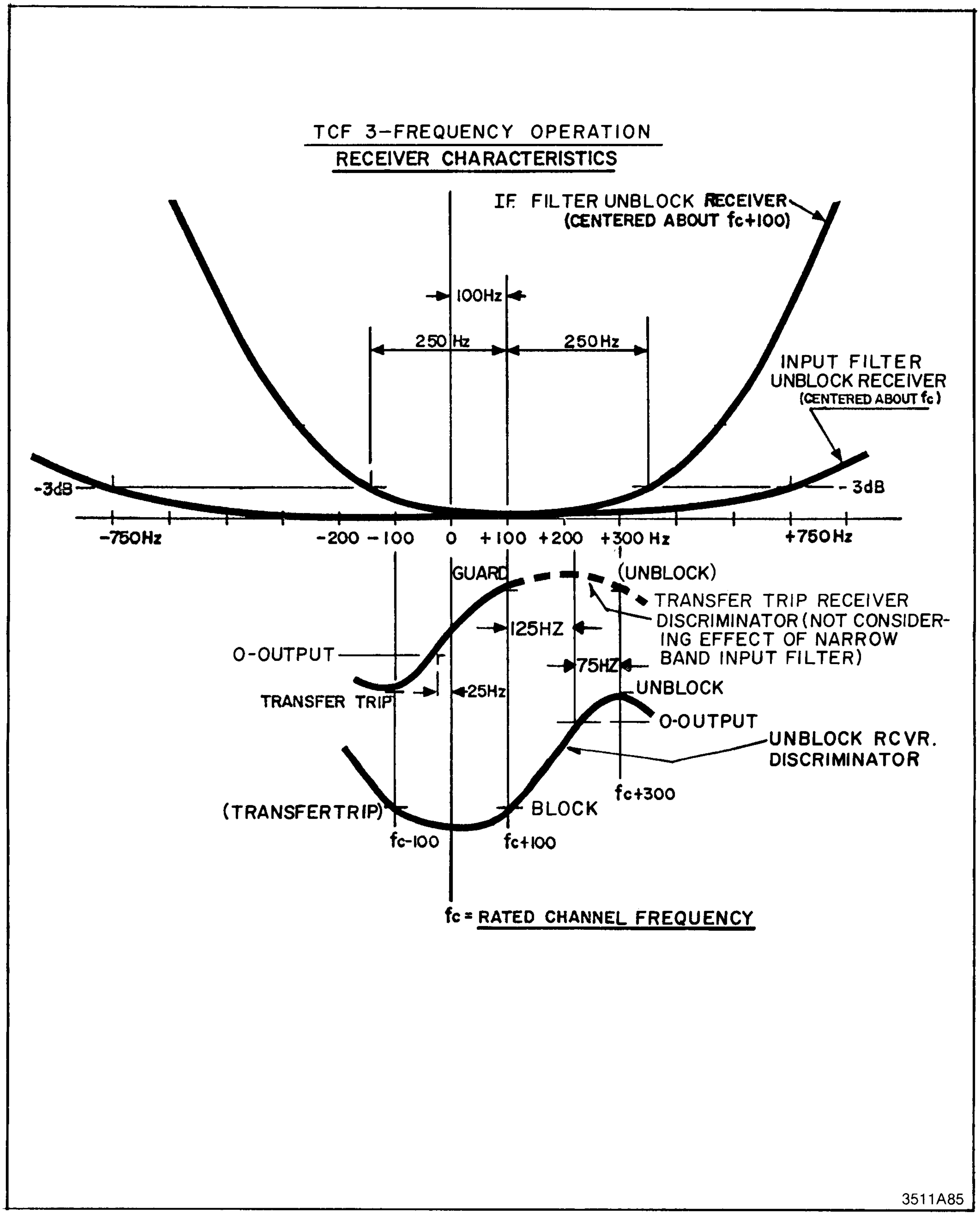


Fig. 9. Three Frequency Operation — Receiver Characteristics

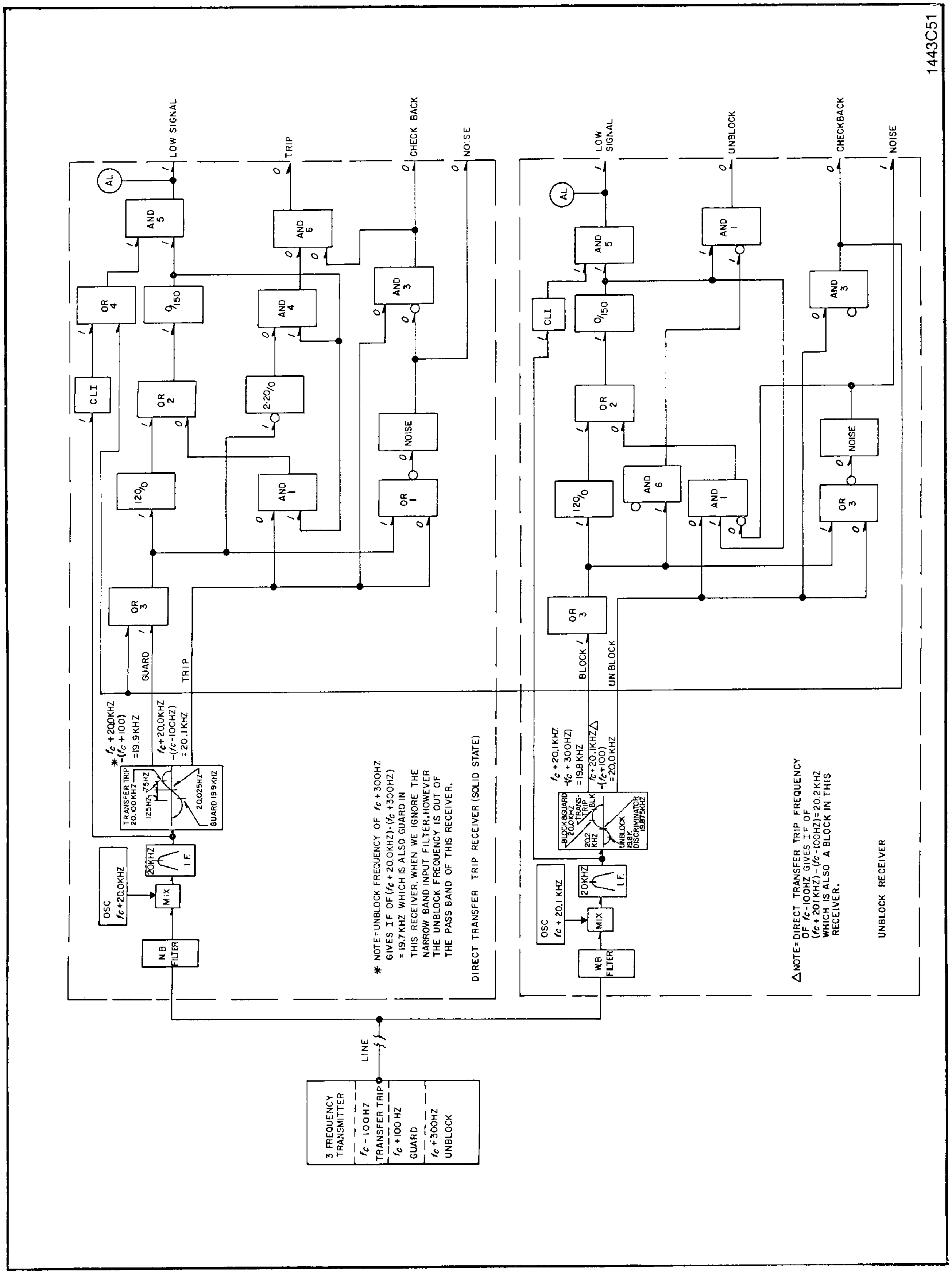


Fig. 10. Receivers Logic Diagram — 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying

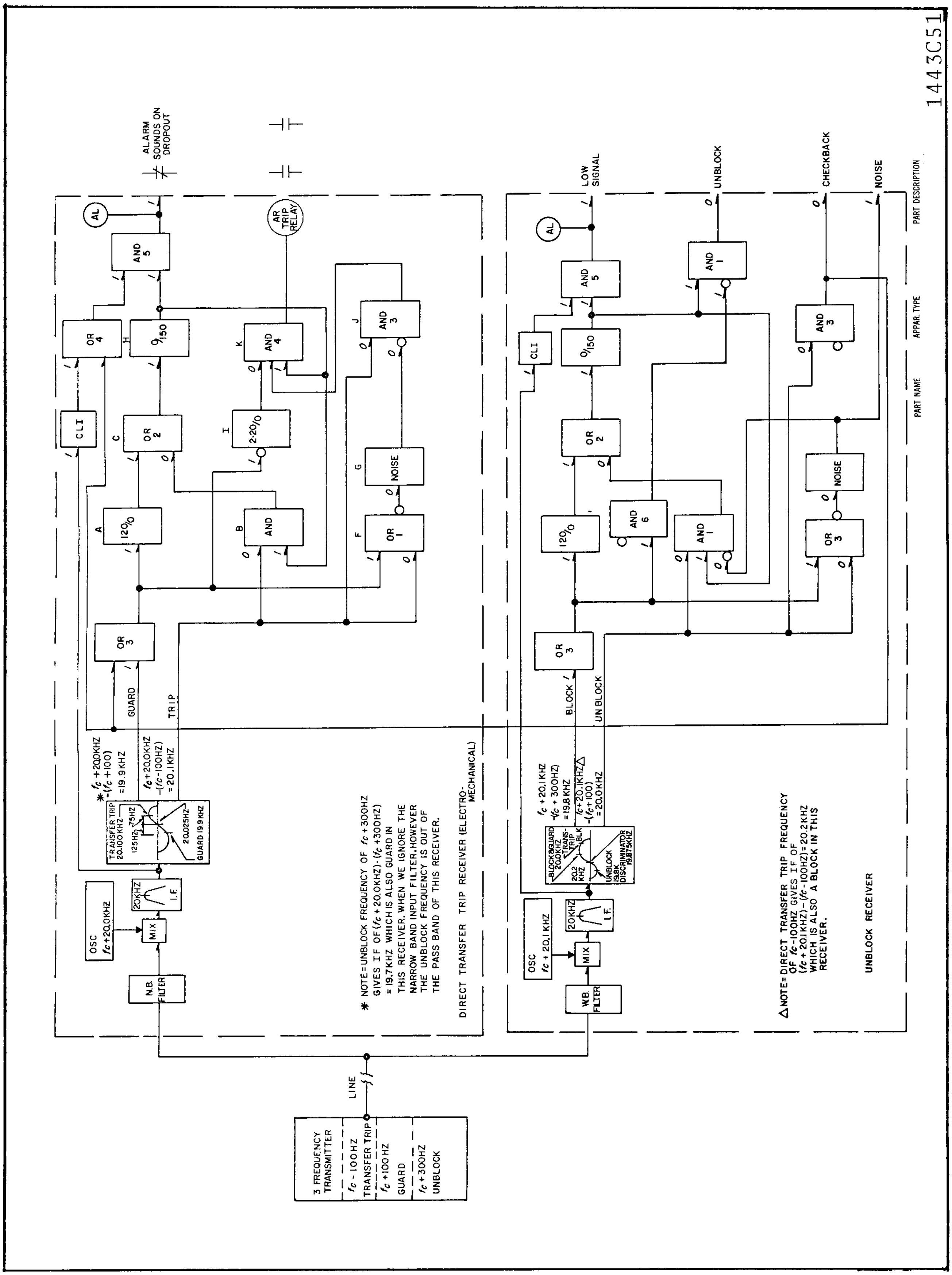


Fig. 11. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

41-945.16

Attached is a copy of "Addendum To IL 41-945.16" for the TCF transmitter. This addendum sheet should be attached to your existing copy of IL 41-945.16 dated January 1976.

To keep our Instruction Leaflets updated, we will now issue an addendum to an existing IL and mail it using the regular means.

Addendums only will be issued to cover the following conditions:

1. An existing error in an IL should be corrected at once.
2. The IL is not entirely clear, added words will make it more understandable.

Relay-Instrument Division

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY — 10 WATT/1-3.25 WATT/10 WATT — WITH VOICE

This sheet notes changes which should be made in instruction leaflet I.L. 41-945.16 dated January 1976.

1. On Page 1, at bottom of page:

   delete reference to "Supersedes I.L. 41-945.12 dated July 1971."

2. On Page 1 at end of APPLICATION section,

   "Figure 7" should read "Figure 9".

3. On Page 1, right hand column, eleventh line

   "This logic is shown in Figure 12"

   should read -

   "This logic is shown in Figures 12 and 13"

4. On page 17:

   "Fig. 10. Receivers Logic Diagrams - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying"

   should read -

   "Fig. 12. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Solid-State Output) and Unblock Relaying"

5. On Page 18:

   "Fig. 13. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying"

   should read -

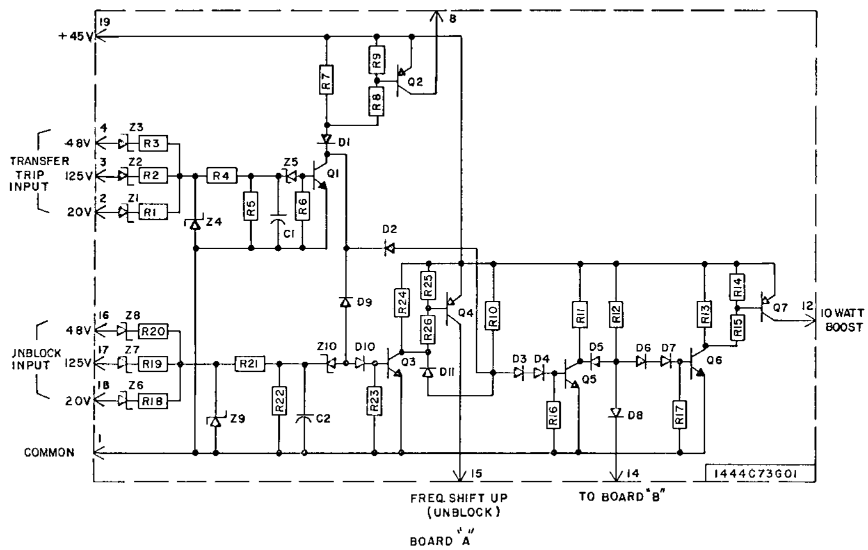
   "Fig. 13. Receiver Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Contact Output) and Unblock Relaying"

6. Add to page 19

   "Fig. 10. Schematic Buffer Keying Circuit Board "A" "

   "Fig. 11. Schematic Buffer Keying Circuit Board "B" "

NOTE: Fig. 10 and 11 are shown on other side of this sheet.



LOGIC BUFFER BD "A" (1444C73G01)

COMPONENT	STYLE	REQ.	REF.
TRANSISTORS			
Q1,Q3,Q5,Q6	184A638H19	4	(2N699)
Q2, Q4, Q7	849A441H02	3	(2N4356)
RESISTORS			
R4 – R21	629A531H36	2	1500 Ohms ½W + 2%
R1 – R18	629A531H38	2	1800 Ohms ½W + 2%
R5 – R22	629A531H51	2	6200 Ohms ½W + 2%
R6-R16-R17-R23	629A531H56	4	10K ½W + 2%
R7-R8-R11-R13-R15-R24-R26	629A531H58	7	12K ½W + 2%
R3 – R20	629A531H62	2	18K ½W +2%
R10 – R12	629A531H66	2	27K ½W +2%
R2 R19	629A531H73	2	51K ½W +2%
R9- R14-R25	629A531H48	3	4.7K ½W +2%
CAPACITORS			
C1 – C2	849A437H04	2	.047 UF
DIODES			
D1,D2,D3,D4,D5,D6,D7,D8,D9,	837A692H03	11	IN645A
D10, D11			
DIO ZENER			
Z4 – Z9	185A212H06	2	IN3686B
Z5 – Z10	186A797H06	2	IN957B
Z1-Z2-Z3-Z6-Z7-Z8	629A369H01	6	1R200

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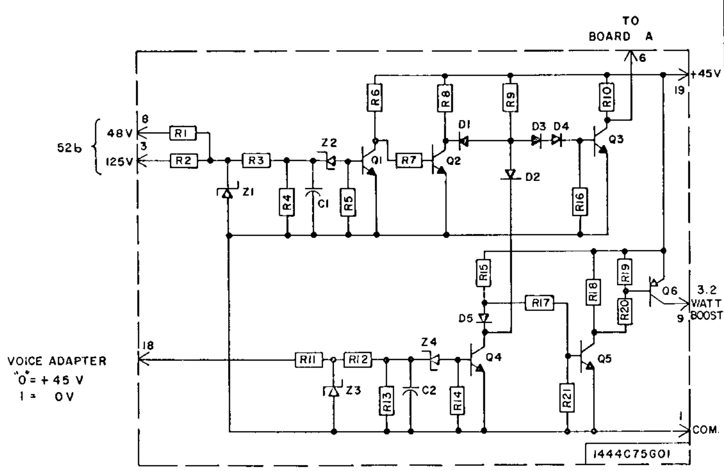
Fig. 10 Buffer Keying Circuit Board "A"



LOGIC BUFFER BD. "B" (1444C75G01)

COMPONENT	STYLE	REQ	REF.
TRANSISTORS			
Q1 - Q2 - Q3 - Q4 - Q5	184A638H19	5	2N699
Q6	849A441H02	1	2N4356
RESISTORS			
R3 - R12	629A531H36	2	1500 Ohms ½W +2%
R4 – R13	629A531H51	2	6200 Ohms ½W +2%
R5-R14-R16-R21	629A531H57	4	11K ½W + 2%
R6-R8-R10-R15-R18-R20	629A531H58	6	12K ½W +2%
R1 – R11	629A531H62	2	18K ½W + 2%
R2	629A531H73	1	51K ½W + 2%
R7-R9-R17	629A531H66	3	27K ½W + 2%
R19	629A531H48	1	4.7K ½W + 2%
CAPACITORS			
C1 – C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5	837A692H03	5	IN645A
DIO ZENER			
Z1 - Z2 - Z3 - Z4	185A212H06	4	IN3686B

775B314

Fig. 11 Buffer Keying Circuit Board "B"

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY — 10 WATT/1-3.25 WATT/10 WATT — WITH VOICE

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 wideband 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" "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 a similar 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 an OR logic circuit). This logic is shown in Figure 12. 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.

The transmitter can also be amplitude modulated at 3.25 watts to provide a voice channel.

CONSTRUCTION

The 10 watt/1-3.25 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. 8. All of the circuitry that is suitable for printed circuit board mounting is on three 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 four printed circuit boards are shown on separate illustrations, Fig. 3, 4, 5, & 6.

External connections to the assembly are made through a 24-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

Supersedes I.L. 41-945.12, dated July 1971
New Information

EFFECTIVE January 1976

Supply voltage variation	42-56v. for nom. 48v. supply. 105-140v. for nom. 125v. supply.	
Battery drain	0.5 a. guard 1.15 a. trip	48 v.d.c.
	0.5 a. guard 0.9 a. trip	125 v.d.c
Keying circuit current	4 ma.	
Temperature range	−20 to +60° 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 car ier 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 60° C.

ADJUSTMENTS

The TCF 10W/1-3.2W/10W 3 Frequency transmitter is shipped with the power output controls R64, R82 and R70, set for outputs of 1 watt, 3.2 watts and 10 watts into a 60 ohm load. If it is desired to check the 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 3 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.

Then change to Trip frequency by connecting together terminals 7 and 12 of the transmitter connector 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 and remove the jumper used to key the transmitter to the 10 watt level. Key for voice by opening any connection terminal to 10 of J3. Turn the power back on. Adjust R82 for a 3.2 watt output across the load resistor (14V across 60 ohms). Open the power switch, reconnect connection to terminal 10 of J3, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

VOLTAGE FOR

T106 TAP	1 WATT OUTPUT	3.2 WATTS OUTPUT	10 WATTS OUTPUT
50	7.1	12.7	22.4
60	7.8	14	24.5
70	8.4	15	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 the 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 and avoids some error from the effect of 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, the Transfer Trip Adjustment with C53, and the unblock frequency with C79.

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 d-c 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 d-c 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 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	Voltage at 3.2 Watts Output (For Voice)
TP52	20	20	20
TP53	5.4	5.4	5.4
TP54	3.4	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	Voltage at 3.2 watts Output (For Voice)
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-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	14

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. Se 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. Se 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. Mimimum 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 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

TRANSMITTER—(6275D85G09)

Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q51-Q52-Q53-Q55	184A638H18	4	2N697
Q54	184A638H19	1	2N699
Q56-Q57	762A672H07	2	2N2726/2N3712
RESISTORS			
R51 to			
R54-R59-R62-R87	184A763H51	7	10K 1/2W ±5%
R56-R57	184A763H40	2	36K 1/2W ±5%
R60-R72	184A763H45	2	5.6K 1/2W ±5%
R61	184A763H55	1	15K 1/2W ±5%
R63	184A763H27	1	1K 1/2W ±5%
R65	184A763H33	1	1.8K 1/2W ±5%
R66	184A763H49	1	8.2K 1/2W ±5%
R67	629A531H58	1	12K 1/2W ±2%
R68	184A763H15	1	330 Ohms 1/2W ±5%
R69	184A859H06	1	800 Ohms 3W ±5%
R71	848A820H27	1	6.49K 1/2W ±1%
R74	629A531H03	1	62 Ohms 1/2W ±2%
R75	187A290H21	1	68+ 1/2W ±5%
R76	184A763H34	2	2K 1/2W ±5%
R77-R78	187A290H01	2	10+ 1/2W ±5%
R79	629A531H63	1	20K 1/2W ±2%
R81	848A819H48	1	1K 1/2W ±1%
R83	848A820H45	1	10K 1/2W ±1%
R84	187A290H01	1	271 1/2W ±5%
R86	848A819H36	1	750 Ohms 1/2W ±1%
R55-R58	184A763H03	2	100 Ohms 1/2W ±5%
CAPACITORS			
C51-C80	762A757H03	2	(1500 MMF)
C54	187A624H01	1	(.1 MFD)
C56-C57	187A584H01	2	2000 MMF
C58-C61-C64-			
C65-C66-C67-C69	187A624H02	7	.25 MFD
C59-C60	762A757H01	2	100 MMF
C62	762A757H04	1	4700 MMF
C63	762A757H02	1	1000 MMF
C68-C75	187A624H03	2	.5 MFD
C74	187A624H04	1	1 MFD
C70	187A584H09	1	300 MMF
C71-C72-C73-C78	861A846H03	4	3 MMF
C76	764A278H10	1	.01 MFD
C77	188A669H01	1	.47 MFD
DIODES			
D51-D52-			
D56-D57-D58	184A855H12	5	(IN628)
D55	184A855H07	1	IN457A
DIO ZENER			
Z54	185A212H06	1	IN3686B
TRANSFORMER			
T51	606B537G01	1	
T52	606B537G02	1	
THERMISTOR			
R73	185A211H06	1	(3D202)
R85	185A211H03	1	3D402
POTENTIOMETER			
R64-R70	619A430H02	2	1K 1/4W ±20%
R80	629A430H09	1	25K 1/4W ±20%
R82	629A430H07	1	5K 1/4W ±20%
TRIMMER			
C52-C53-C55-C79	879A834H01	4	5.5 18PF

LOGIC BUFFER BD. "B" (1444C75G01)

Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q1-Q2-Q3-Q4-Q5	184A638H19	5	2N699
Q6	849A441H02	1	2N4356
RESISTORS			
R3-R12	629A531H36	2	1500 Ohms 1/2W ±2%
R4-R13	629A531H51	2	6200 Ohms 1/2W ±2%
R5-R14-R16-R21	629A531H57	4	11K 1/2W ±2%
R6-R8-R10-			
R15-R18-R20	629A531H58	6	12K 1/2W ±2%
R1-R11	629A531H62	2	18K 1/2W ±2%
R2	629A531H73	1	51K 1/2W ±2%
R7-R9-R17	629A531H66	3	27K 1/2W ±2%
R19	629A531H48	1	4.7K 1/2W ±2%
CAPACITORS			
C1-C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5	837A692H03	5	IN645A
DIO ZENER			
Z1-Z2-Z3-Z4	185A212H06	4	IN3686B

ELECTRICAL PARTS LIST (Cont'd.)

POWER AMP (606B530)

Components	*Style*	*Req.*	*Ref.*
RESISTORS			
R101-R105	187A290H01	2	10 Ohms 1/2W ±5%
R102	187A644H35	1	2.2K 1W ±10%
R103-R107	184A636H14	2	2.7Ω 1/2W ±10%
R104-R108	184A636H18	2	0.27Ω 1W ±10%
R106	187A644H43	1	4.7K 1W ±10%
CAPACITORS			
C101-C102	187A624H02	2	.25 MFD, 200V DC
C103-C104	S. No. PER S.O.	2	
DIODES			
D102-D104		2	See Note Δ
D101-D103	188A342H06	2	IN4818

LOGIC BUFFER BD. "A" (1444C73G01)

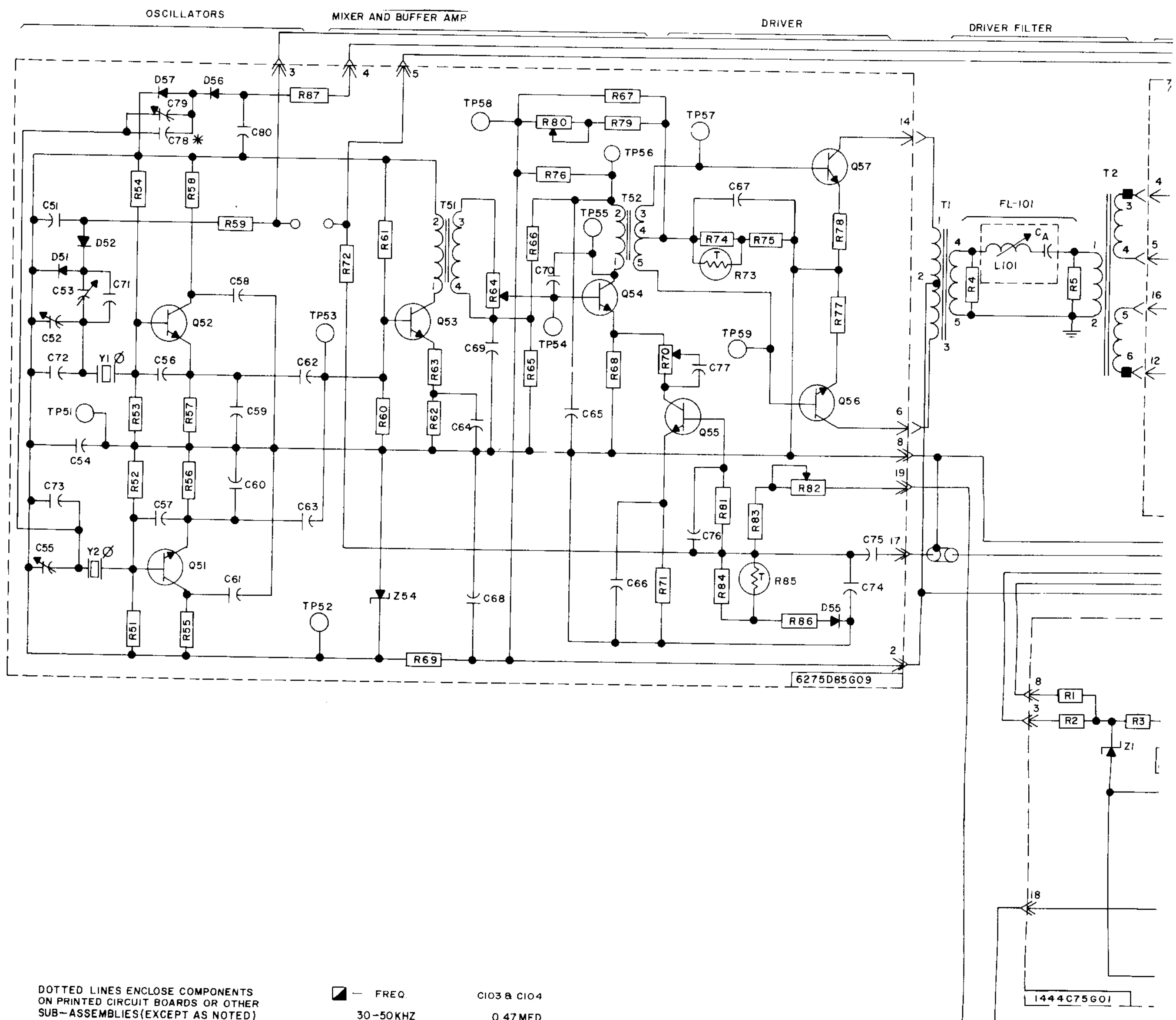
Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q1-Q3-Q5-Q6	184A638H19	4	(2N699)
Q2-Q4-Q7	849A441H02	3	(2N4356)
RESISTORS			
R4-R21	629A531H36	2	1500 Ohms 1/2W ±2%
R1-R18	629A531H38	2	1800 Ohms 1/2W ±2%
R5-R22	629A531H51	2	6200 Ohms 1/2W ±2%
R6-R16-R17-R23	629A531H56	4	10K 1/2W ±2%
R7-R8-R11-R13-R15-R24-R26	629A531H58	7	12K 1/2W ±2%
R3-R20	629A531H62	2	18K 1/2W ±2%
R10-R12	629A531H66	2	27K 1/2W ∓2%
R2-R19	629A531H73	2	51K 1/2W ±2%
R9-R14-R25	629A531H48	3	4.7K 1/2W ±2%
CAPACITORS			
C1-C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5-D6-D7-D8-D9 D10-D11	837A692H03	11	IN645A
DIO ZENER			
Z4-Z9	185A212H06	2	IN3686B
Z5-Z10	186A797H06	2	IN957B
Z1-Z2-Z3-Z6-Z7-Z8	629A369H01	6	IR200

OUTPUT FILTER

Component	*Style*	*Req.*	*Ref.*
FL-102	S. No. PER S.O.	1	541D214 200KHz
FL-102	S. No. PER S.O.	1	5481D10 200 to 300KHz

OTHER

Component	*Style*	*Req.*	*Ref.*
RESISTORS			
R1-R2	04D1299H44	2	26.5 OHMS
R3	04D1299H44	1	26.5 Ohms 48V DC
R3	1268047	1	500 Ohms 125V DC
R4	187A644H03	1	100 Ohms
R5	187A641H27	1	1K 10% 1/2W
R6	188A317H01	1	3000 Ohms 5W ±5%
CAPACITORS			
C1	1723408	1	(0.45 MFD)
C2-C3	1877962	2	(0.5 MFD)
DIODE			
D1	188A342H06	1	(IN4818)
DIODE-ZENER			
Z3	584C434H08	1	(IN1789)
Z1	184A854H06	1	(IN2828B)
Z2	184A617H12	1	(IN3009A)
TRANSISTOR			
Q1	3503A41H01	1	(2N6259)
TRANSFORMERS			
T1	606B410G01	1	
T2	292B526G01	1	
T3	292B526G02	1	
FILTER			
FL-101	S. No. PER S.O.	1	408C261 30-200KC
FL-101	S. No. PER S.O.	1	202C074 200 to 300KC
TELEPHONE JACK	187A606H01	1	J1



DOTTED LINES ENCLOSE COMPONENTS ON PRINTED CIRCUIT BOARDS OR OTHER SUB–ASSEMBLIES(EXCEPT AS NOTED)

J3

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24

(AS VIEWED FROM REAR SIDE OF PANEL)

◪ — FREQ	C103 & C104
30–50KHZ	0.47MFD
50.5–75KHZ	0.22MFD
75.5–100KHZ	0.15MFD
100.5–150KHZ	0.10MFD
150.5–300KHZ	0.047MFD

◆–MOUNTED ON LARGE HEAT SINKS

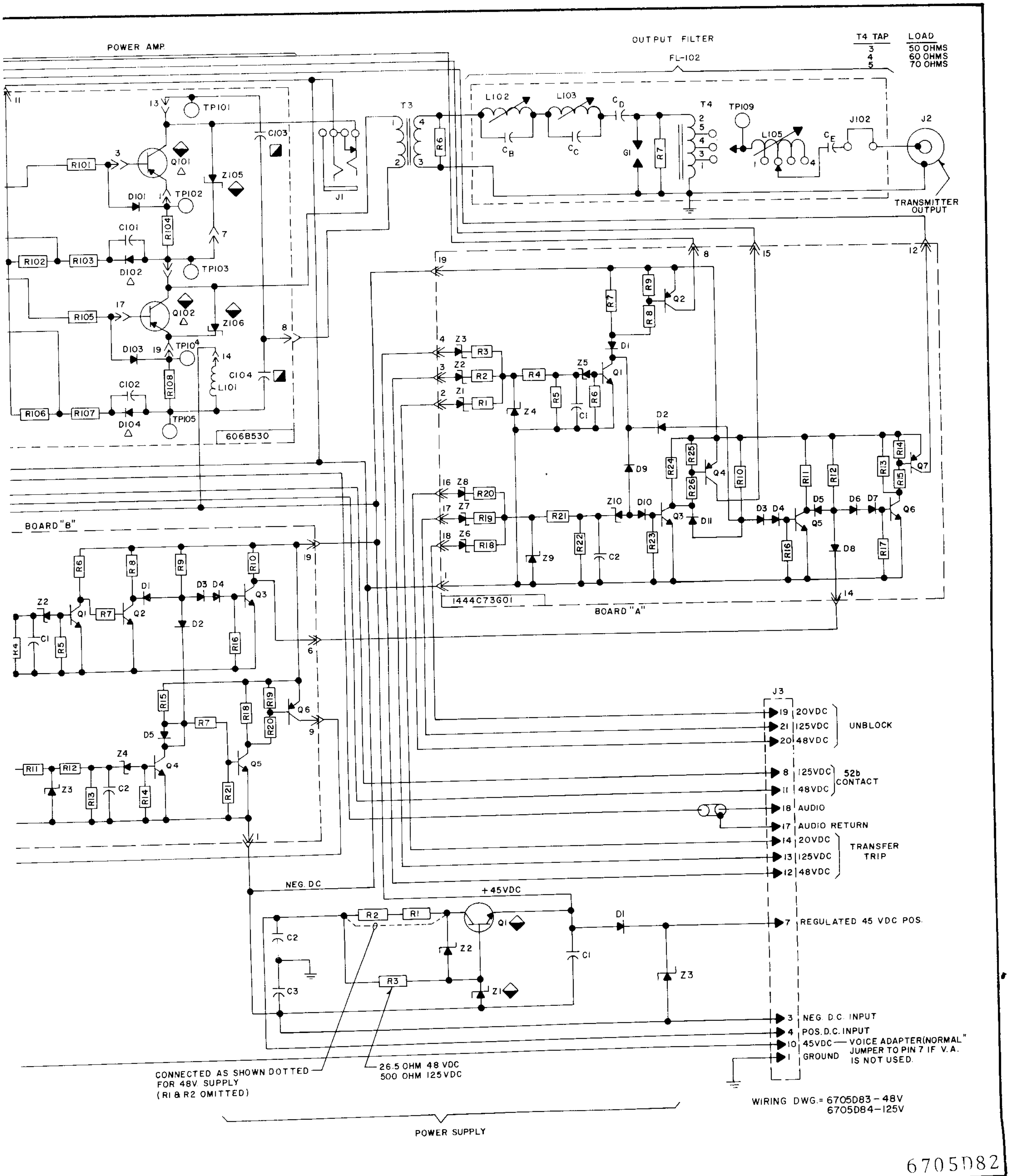
∅– MATCHED PAIR
Y1–2.03 TO 2.30MHZ
Y2–2.00MHZ

✱–C78 SUPPLIED IF REQUIRED IN TEST

△–FOR SILICON VERSION USE 2N3792 S# 187A673H16, WITH DIODES D102 & D104, 1N4818 S# 188A342H06 ON BD. STYLES 606B530G08 TO G12.

ALL CAPACITORS ARE IN MFD. EXCEPT AS NOTED.

Fig. 1. Internal Schematic of the Type TCF 3-Frequen



cy, 10 Watt/1 Watt/10 Watt Transmitter.

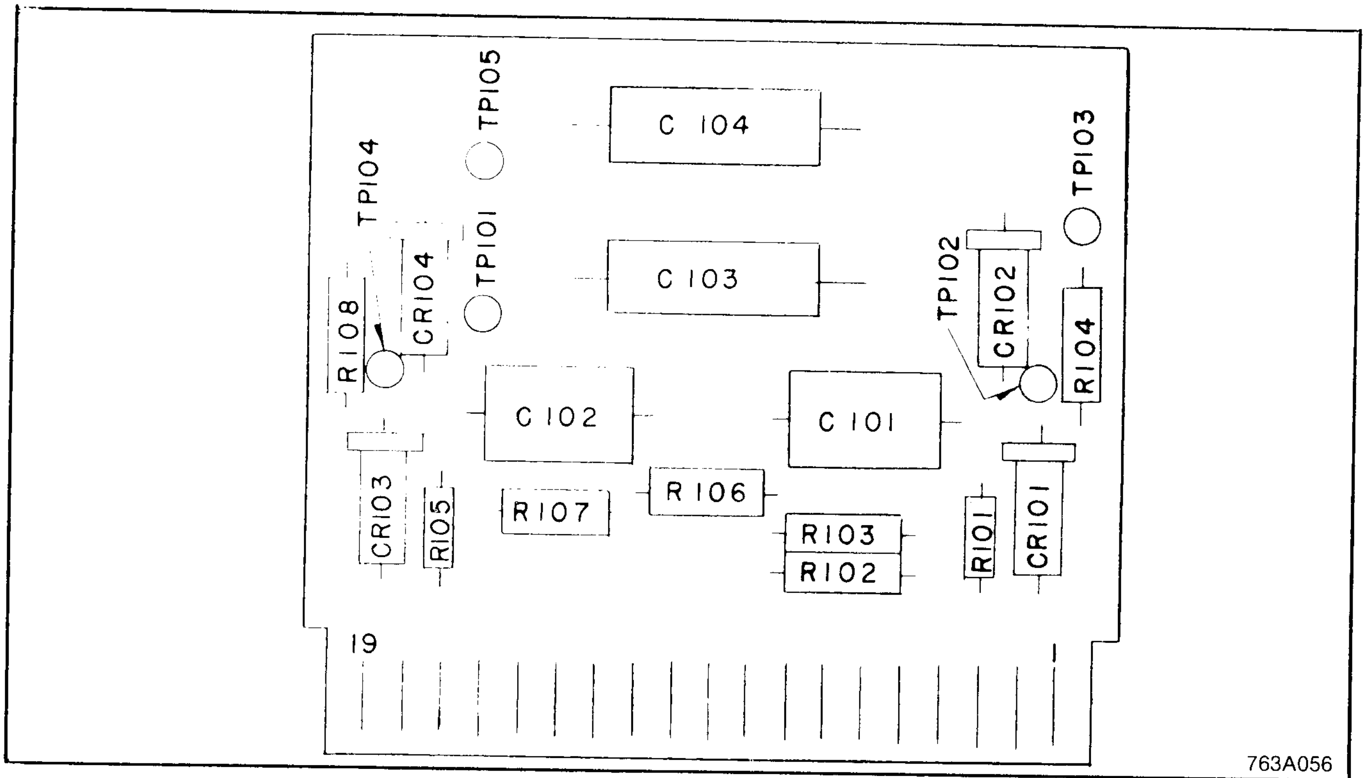


Fig. 4. Component Locations of the Power Amplifier Printed Circuit Board

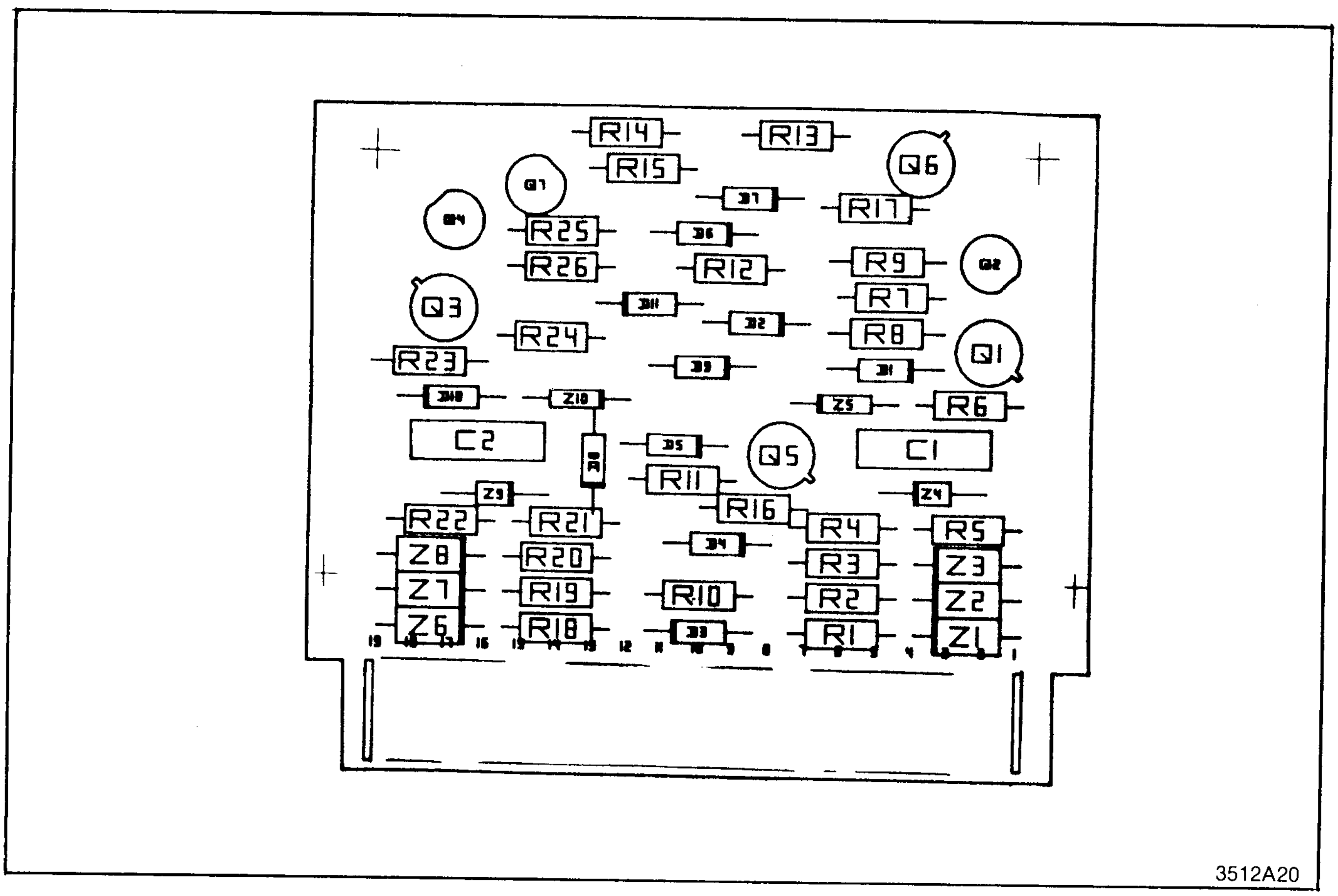


Fig. 5. Component Location of Buffer Keying Circuit Board A

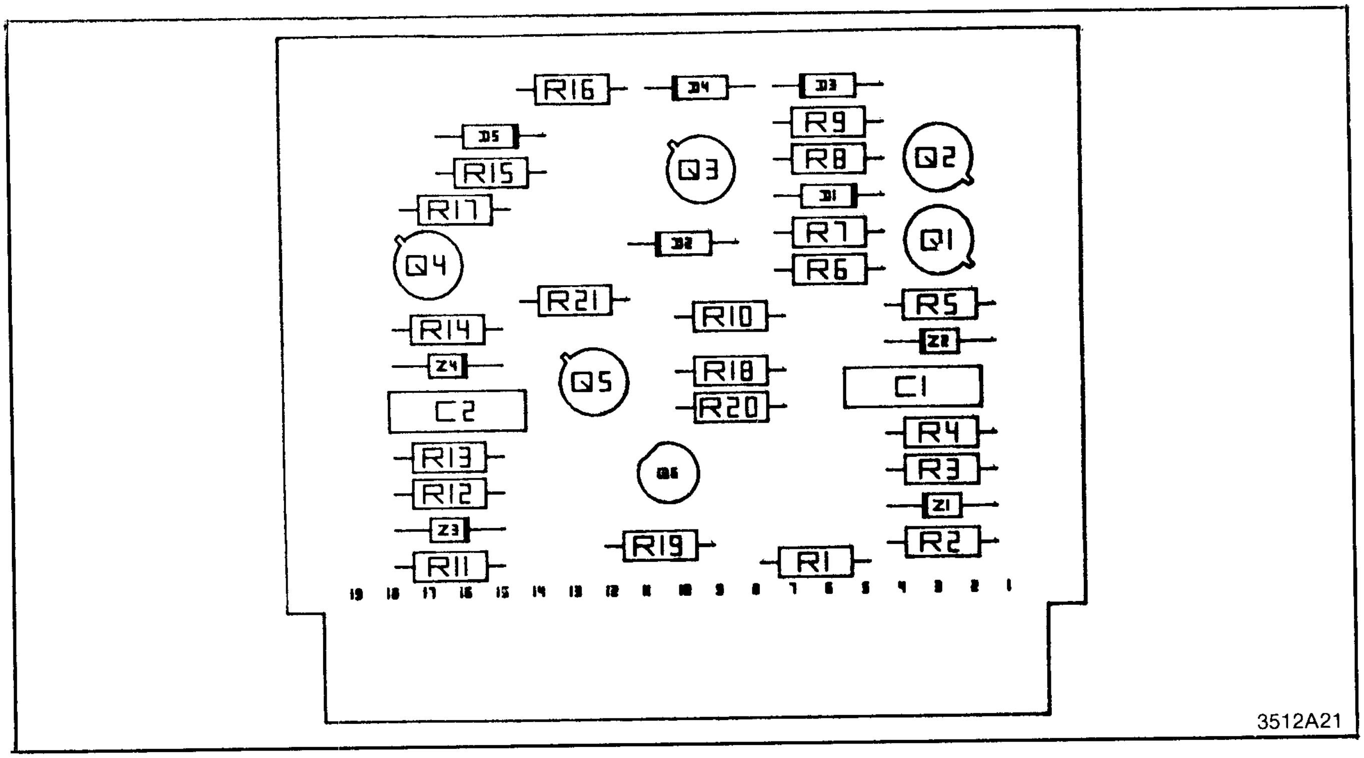
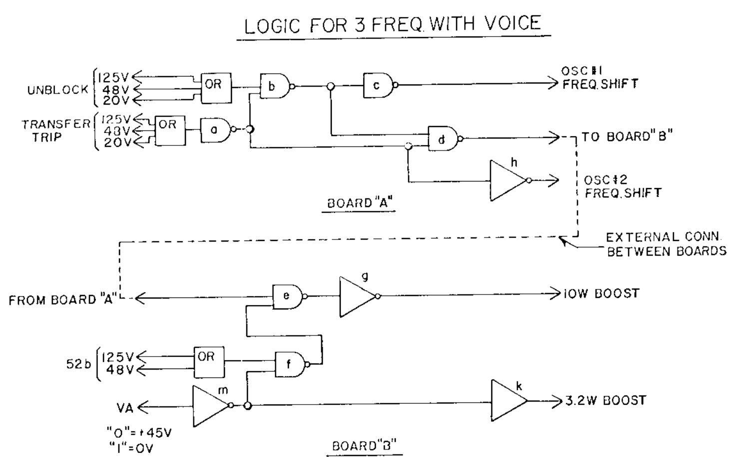


Fig. 6. Component Location of Buffer Keying Circuit Board B



TRUTH TABLE–3 FREQ. WITH VOICE

INPUT KEYING				OUTPUTS				
UN	TT	52b	VA	TT FREQ. SHIFT	UN FREQ. SHIFT	3.2W BOOST	10W BOOST	
0	0	0	0	0	0	0	0	GUARD @ 1W
1	0	0	0	0	1	0	1	UNBLK. @ 10W
1	1	0	0	1	0	0	1	T.T. 10W @
1	0	1	0	0	1	0	1	UNBLK. @ 10W
1	0	0	1	0	1	0	1	UNBLK. @ 10W
1	1	1	0	1	0	0	1	TT 10W @
1	0	1	1	0	1	1	0	UNBLK 3.2W @
1	1	0	1	1	0	0	1	TT 10W @
1	1	1	1	1	0	1	0	TT 3.2W @
0	1	0	0	1	0	0	1	TT 10W @
0	1	1	0	1	0	0	1	TT 10W @
0	1	0	1	1	0	0	1	TT 10W @
0	1	1	1	1	0	1	0	TT 3.2W @
0	0	1 ✻	0	0 ✻	1	0	1	UNBLK @ 10W
0	0	1 ✻	1	0 ✻	1	1	0	UNBLK 3.2W @
0	0	0	1	0	0	1	0	GUARD @ 3.2W

✻ = STU RELAY AFTER 180MS OPERATION OF 52b WILL KEY TO UNBLOCK. IN THIS CASE, THE UNBLOCK KEYING IS NOT DONE BY THE LOGIC REPRESENTED BY THESE LOGIC BOARDS.

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Fig. 7. Logic Drawing for 3 Frequency with Voice.

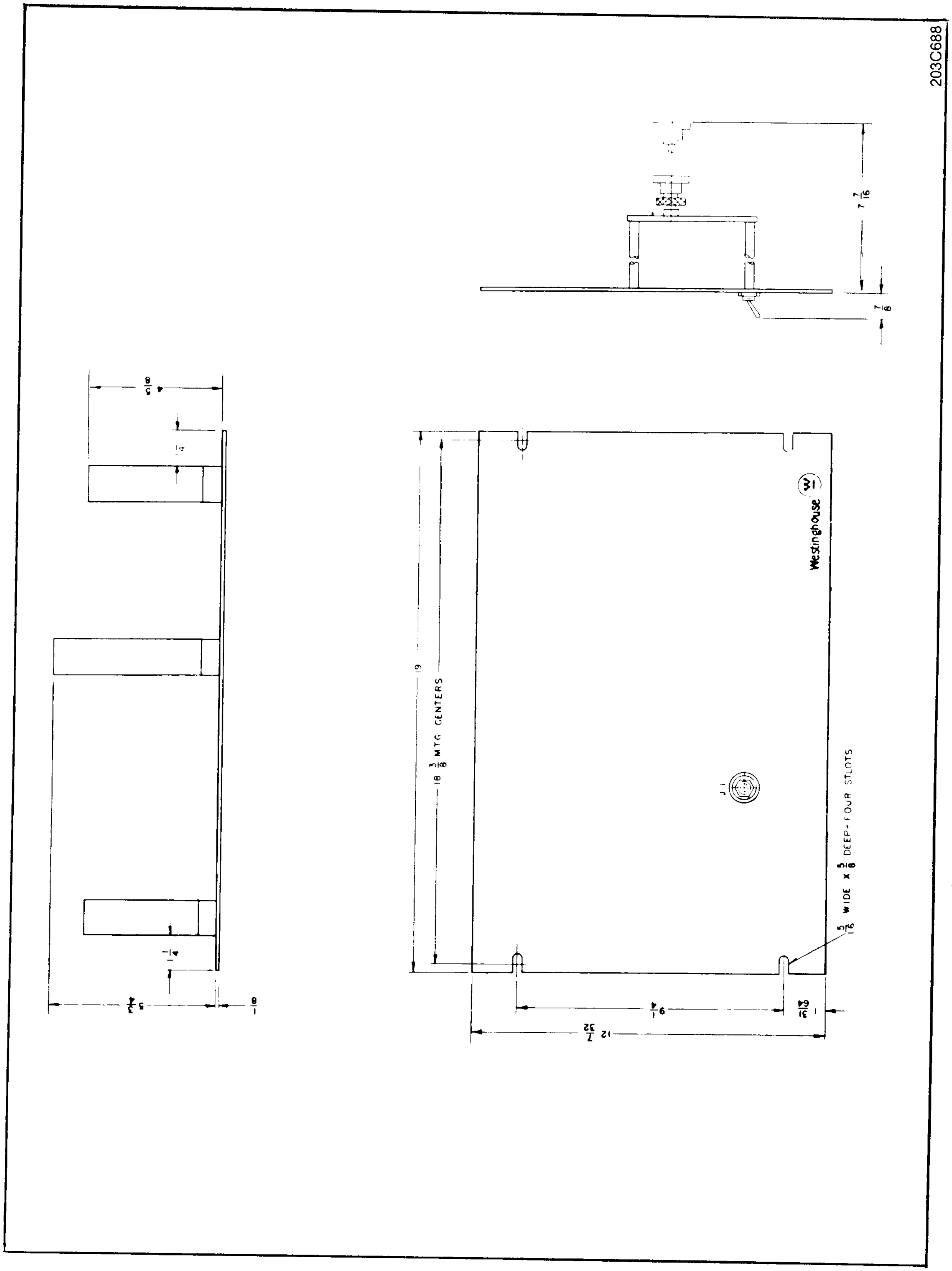

Fig. 8. Outline and Drilling Plan for the Type TCF Transmitter Assembly

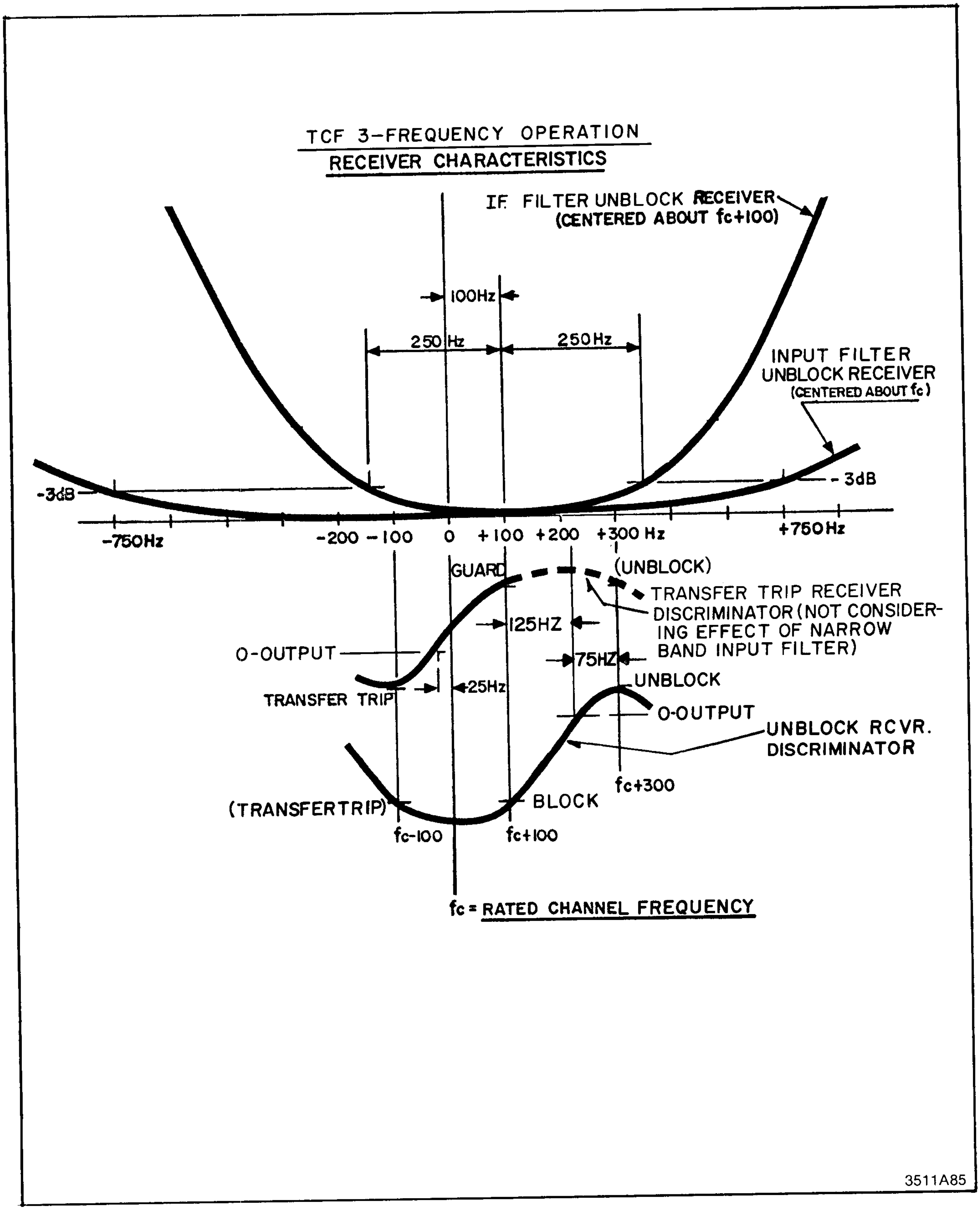

Fig. 9. Three Frequency Operation — Receiver Characteristics

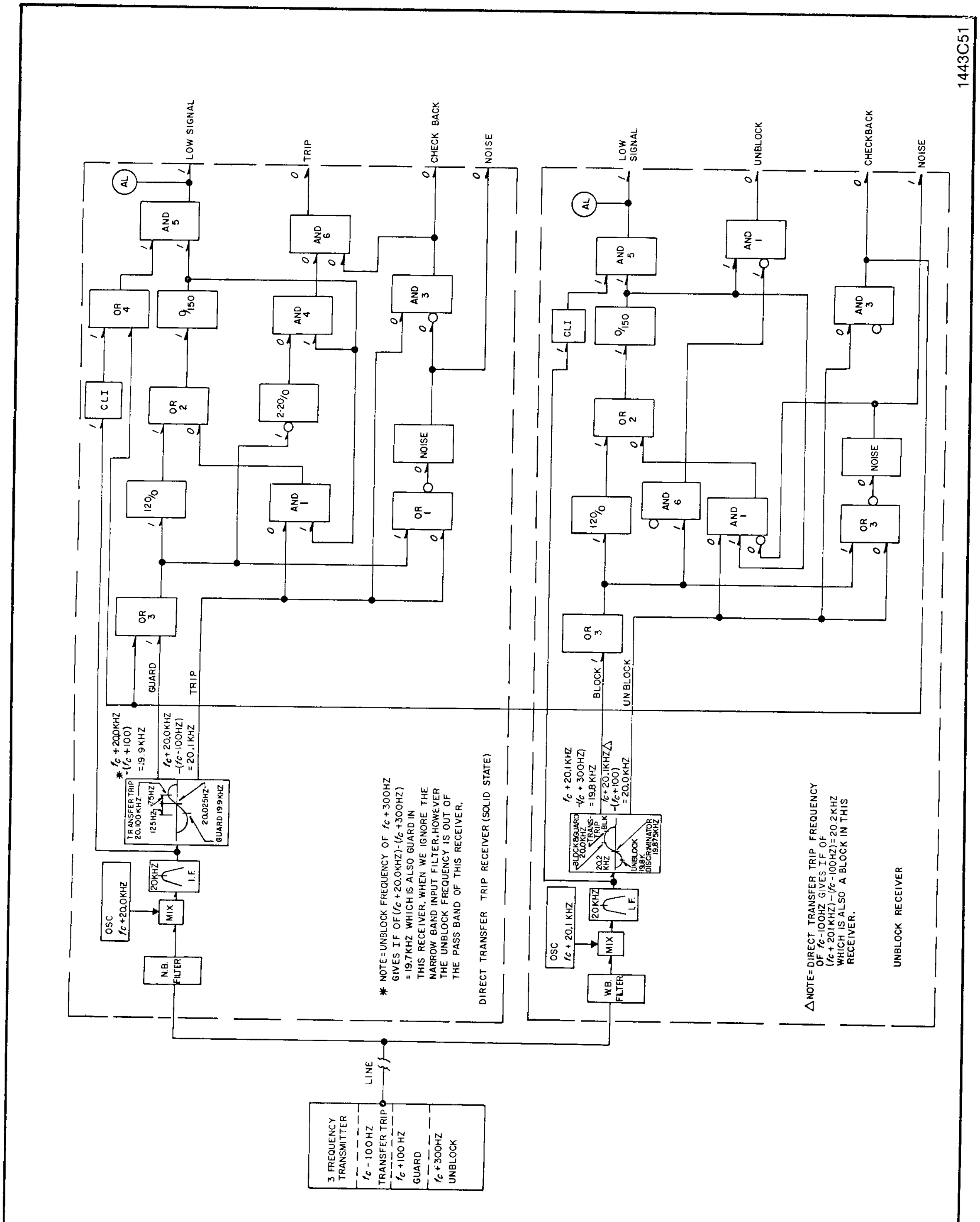

Fig. 10. Receivers Logic Diagram — 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying

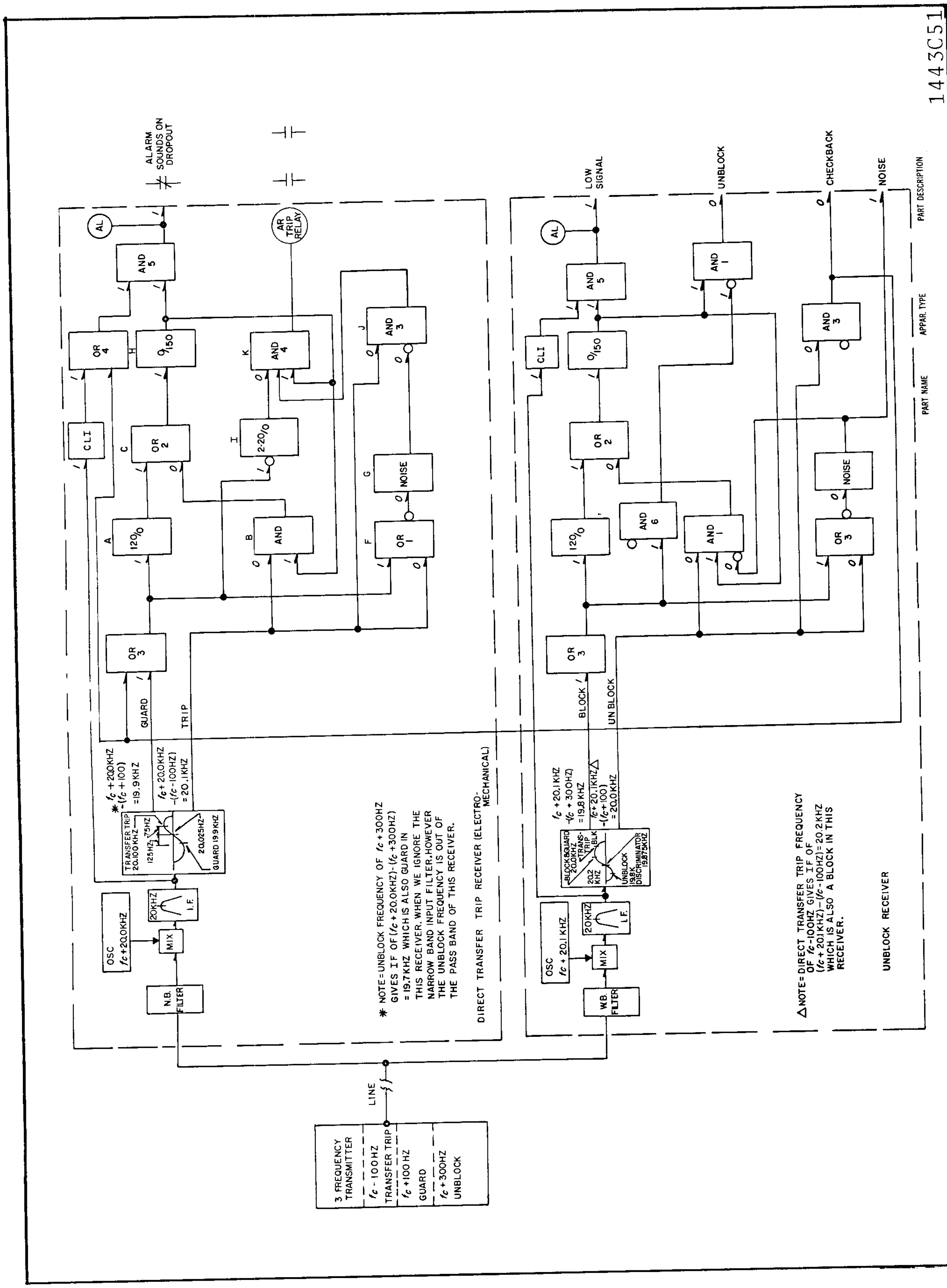

Fig. 11. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying

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RELAY-INSTRUMENT DIVISION

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