Westinghouse I.L. 41-945.4A

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER TRANSMITTER EQUIPMENT – 10 WATT OUTPUT – FOR MULTI-STATION SUPERVISORY CONTROL

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

The TCF power line carrier transmitter equipment for multi-station supervisory control applications is similar in appearance to the TCF 1 watt/10 watt transmitter for transfer-trip relaying applications. However, because a Guard frequency cannot be used in multi-station supervisory control applications, the transmitter is connected so that it has no output until the keying contact is closed. It then provides 10 watts output at a frequency 100 hertz below the channel center frequency (which would be called the
* Trip frequency in transfer-trip applications). The center frequency (fc) of the channel can have any value between 30kHz and 200kHz in 0.5kHz steps. This high frequency is superposed on a high voltage power line through a line tuner and coupling equipment, and through similar coupling equipment at remote stations it activates receiving equipment that is tuned to the same frequency.

The transmitter is designed to hold its frequency within close limits since it is used with receiving equipment that has a high degree of frequency selectivity. This minimizes the possibility of false operation of a receiver resulting from random transient frequencies produced by line disturbances or by other causes.

CONSTRUCTION

The 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. All components are mounted on the rear of the panel. Fuses, a pilot light, a power switch and a jack for metering the amplifier collector current are accessible from the front of the panel. See Fig. 5. 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 two printed circuit boards are shown on separate illustrations, Fig. 3 & 4.

External connections to the assembly are made through a 12-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

SUPERSEDES I.L. 41-945.4
*Denotes change from superseded issue.

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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 frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. One filter is located between the driver and the power amplifier and the final filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30kHz to 200kHz range cannot be forced to oscillate
* away from its natural frequency by as much as ± 100 hertz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2MHz 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 frequency, or 2.03 MHz to 2.20 MHz. 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 follower mode. The emitter is coupled to the base through C57, and 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.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes CR51 and CR52. By adjustment of C52 this circuit can be made to oscillate at 100 hertz above its marked frequency. This adjustment is required when the transmitter must have a Guard frequency output. Capacitor C53 is not
* effective until CR51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until a voltage of sufficient magnitude is applied at terminal 3 of the printed circuit board. In two-frequency applications, 45 V.D.C. is so applied by closure of a control or keying contact, but in the single-frequency application terminal 3 is permanently connected to the 45 volt supply. With CR51 conducting, C53 is effectively in parallel with C52, and adjustment of C53 will reduce the frequency by 200 hertz.

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 hertz over a temperature range of -20 to ±60° 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.

In a 1 watt/10 watt transmitter for transfer-trip relaying, the output is increased from 1 to 10 watts by closure of the same contact that changes the frequency from Guard to Trip. This contact applies 45 V.D.C. at terminal 3 of the printed circuit board, and thus supplies base input to transistor Q55 through diode CR53 and resistor R72. This in effect places potentiometer R70 in parallel with emitter resistor R68, and by adjusting the amount of resistance in R70 that is not bypassed by C66 the output of buffer-amplifier transistor Q54 can be increased by the amount required to obtain 10 watts output from the transmitter. In the transmitter for multi-stations supervisory control CR51 and Q55 are conductive at all times, and the transmitter will have output at the desired level and frequency when voltage is supplied to the collectors of Q54 and driver stage transistors Q56 and Q57 by closure of a control contact connected between terminals J3-7 and J3-8. 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, and opening the single power switch deenergizes both the transmitter and the keying circuit.

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 temperature on the input level.

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 the 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 CR101 and CR103 provide protection for the base-emitter junctions of the power transistors. Zener diodes CR105 and CR106 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, C_B and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D 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 tuner 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 C_E 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 reverse 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 standby current drain when there is no output current demand. The zener diode VR1 holds 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 VR2 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 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

* CHARACTERISTICS

Frequency range	30-200 kHz
Output	10 watts (into 50 to 70 ohm resistive load)
Frequency stability	± 10 hertz from -20° C to +60° C.
Frequency spacing	3 kHz 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. 48 v. supply. 105-140 v. for nom. 125 v. supply.
Battery drain–not transmitting	0.25 a.
Battery drain–transmitting	1.15 a. for 48 v. supply 0.9 a. for 125 v. supply
Keying circuit current	0.02 a.
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 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 60 °C.

ADJUSTMENTS

The TCF transmitter is shipped with the power output controls R64 and R70 adjusted to the positions that would be used for the transfer-trip transmitter with 1 watt Guard and 10 watts Trip outputs into a 60 ohm load. The single 10 watt output required for multi-station supervisory control can be obtained with various combinations of settings of R64 and R70., but in case repairs have made readjustment necessary the following procedure is preferred. 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. Connect a short clip lead across R71 so that Q55 will be kept non-conductive. Turn power controls R64 and R70 to minimum (full counterclockwise). 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.

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

Remove the lead that was connected across R71 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 load resistor, and reconnect the coaxial cable circuit to the transmitter.

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 2.2 magahertz 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 a minor adjustment of the output frequency should be needed, this can be made with capacitor C53.

MAINTENANCE

Periodic checks of the transmitter power output 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 1

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 10 Watts Output
TP52	20
TP53	5.4
TP54	3.4
TP55	18.5
TP56	18.5
TP57	<1
TP58	45
TP59	<1
TP101	0
TP103	21 ± 2
TP105	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 voltages read with a-c VTVM.

Test Point	Voltage at 10 Watts Output	Test Point	Voltage at 10 Watts Output
TP54 to TP51	0.015 – 0.03	T2-1 to Gnd.	1.85
TP57 to TP51	0.3 – 1.2	TP101 to TP103	17.0
TP59 to TP51	0.3 – 1.2	TP103 to TP105	17.0
		T3-4 to Gnd.	112
T1-1 to TP51	5.6	T4-2 to Gnd.	110
T1-3 to TP51	4.9	TP109 to Gnd.	31
T1-4 to Gnd.	2.0	J102 to Gnd.	24.5

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 cycles/sec. to 230-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 230-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.

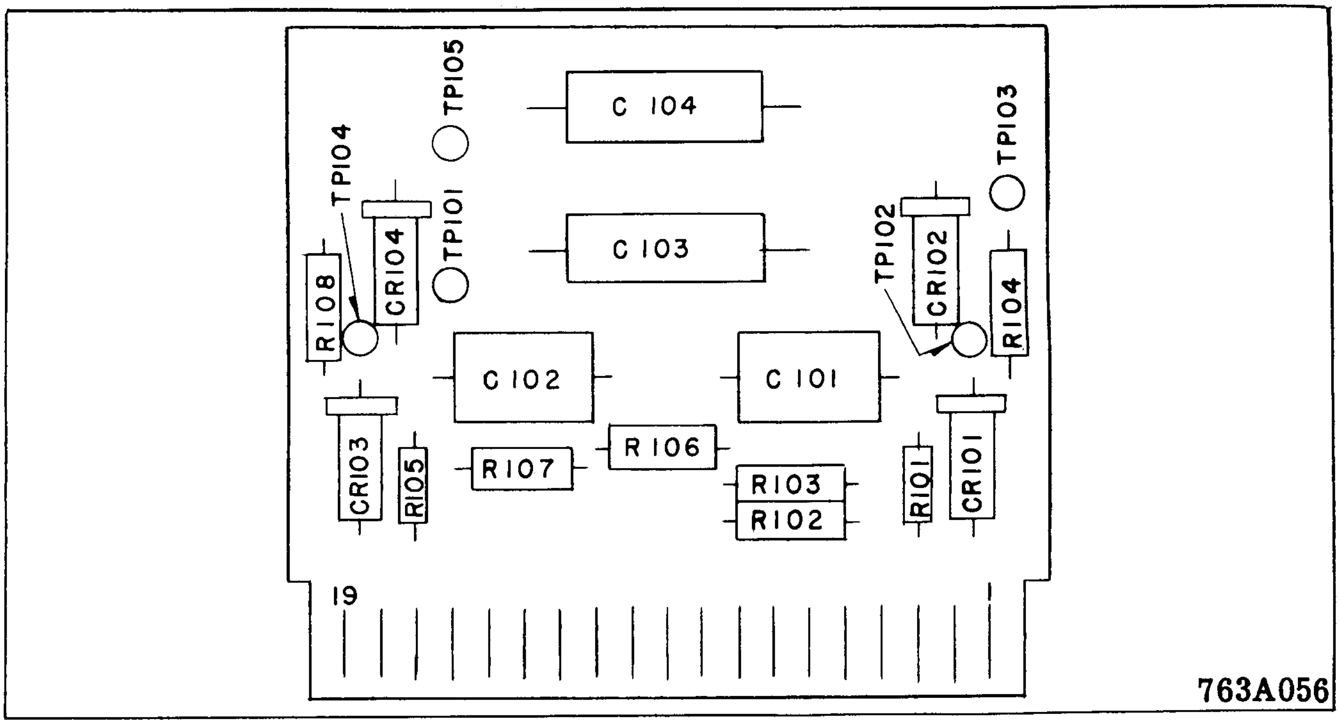

Fig. 4 Component locations of the Power Amplifier printed circuit board.

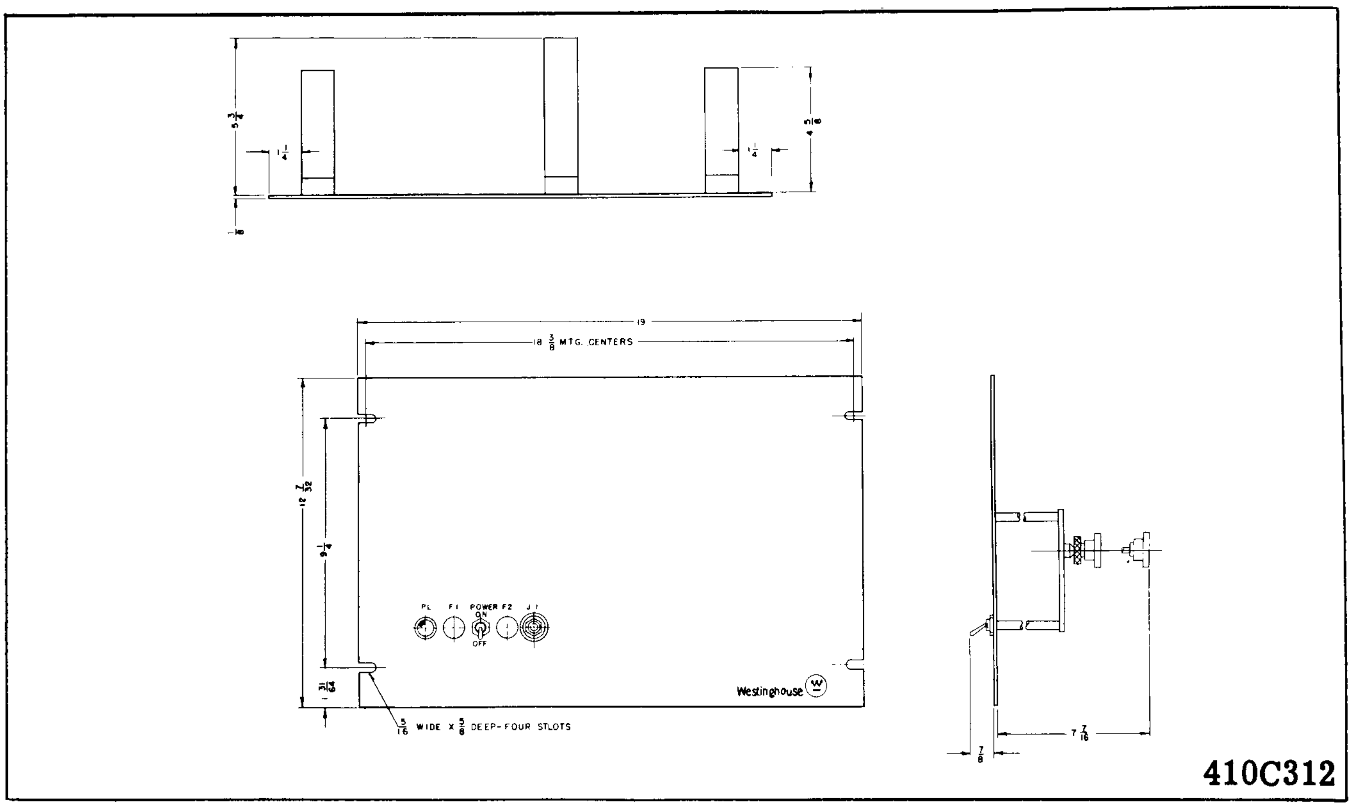

Fig. 5 Outline and drilling plan for the type TCF transmitter assembly.

WESTINGHOUSE ELECTRIC CORPORATION
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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER TRANSMITTER EQUIPMENT – 10 WATT OUTPUT – FOR MULTI-STATION SUPERVISORY CONTROL

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

The TCF power line carrier transmitter equipment for multi-station supervisory control applications is similar in appearance to the TCF 1 watt/10 watt transmitter for transfer-trip relaying applications. However, because a Guard frequency cannot be used in multi-station supervisory control applications, the transmitter is connected so that it has no output until the keying contact is closed. It then provides 10 watts output at a frequency 100 cycles below the channel center frequency (which would be called the Trip frequency in transfer-trip applications). The center frequency (fc) of the channel can have any value between 30KC and 200KC in 0.5 KC steps. This high frequency is superposed on a high voltage power line through a line tuner and coupling equipment, and through similar coupling equipment at remote stations it activates receiving equipment that is tuned to the same frequency.

The transmitter is designed to hold its frequency within close limits since it is used with receiving equipment that has a high degree of frequency selectivity. This minimizes the possibility of false operation of a receiver resulting from random transient frequencies produced by line disturbances or by other causes.

CONSTRUCTION

The 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. All components are mounted on the rear of the panel. Fuses, a pilot light, a power switch and a jack for metering the amplifier collector current are accessible from the front of the panel. See Fig. 5. 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 two printed circuit boards are shown on separate illustrations, Fig. 3 & 4.

External connections to the assembly are made through a 12-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

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 frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. One filter is located between the driver and the power amplifier and the final filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 KC to 200 KC range cannot be forced to oscillate away from its natural frequency by as much as ±100 cycles. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MC range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MC when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MC plus the channel frequency, or 2.03 MC to 2.20 MC. 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 follower mode. The emitter is coupled to the base through C57, and 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.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes CR51 and CR52. By adjustment of C52 this circuit can be made to oscillate at 100 cycles above its marked frequency. This adjustment is required when the transmitter must have a Guard frequency output. Capacitor C53 is not effective until CR51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until a voltage of sufficient magnitude is applied at terminal 3 of the printed circuit board. In two-frequency applications, 45 V.D.C. is so applied by closure of a control or keying contact, but in the single-frequency application terminal 3 is permanently connected to the 45 volt supply. With CR51 conducting, C53 is effectively in parallel with C52, and adjustment of C53 will reduce the frequency by 200 cycles.

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 cycles/sec. over a temperature range of -20 to ± 60 °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.

In a 1 watt/10 watt transmitter for transfer-trip relaying, the output is increased from 1 to 10 watts by closure of the same contact that changes the frequency from Guard to Trip. This contact applies 45 V.D.C. at terminal 3 of the printed circuit board, and thus supplies base input to transistor Q55 through diode CR53 and resistor R72. This in effect places potentiometer R70 in parallel with emitter resistor R68, and by adjusting the amount of resistance in R70 that is not bypassed by C66 the output of buffer-amplifier transistor Q54 can be increased by the amount required to obtain 10 watts output from the transmitter. In the transmitter for multi-stations supervisory control CR51 and Q55 are conductive at all times, and the transmitter will have output at the desired level and frequency when voltage is supplied to the collectors of Q54 and driver stage transistors Q56 and Q57 by closure of a control contact connected between terminals J3-7 and J3-8. 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, and opening the single power switch deenergizes both the transmitter and the keying circuit.

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 temperature on the input level.

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 the 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 CR101 and CR103 provide protection for the base-emitter junctions of the power transistors. Zener diodes CR105 and CR106 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, C_B and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D 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 tuner 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 C_E 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 reverse 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 standby current drain when there is no output current demand. The zener diode VR1 holds 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 VR2 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 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

CHARACTERISTICS

Frequency range	30-200 KC
Output	10 watts (into 50 to 70 ohm resistive load)
Frequency stability	± 10 cycles/sec. from −20 °C to +60 °C.
Frequency spacing	3 KC min. between transmitter and adjacent receive 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. 48 v. supply. 105-140 v. for nom. 125 v. supply.
Battery drain–not transmitting	0.25 a.
Battery drain–transmitting	1.15 a. for 48 v. supply 0.9 a. for 125 v. supply
Keying circuit current	0.02 a.
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 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 60 °C.

ADJUSTMENTS

The TCF transmitter is shipped with the power output controls R64 and R70 adjusted to the positions that would be used for the transfer-trip transmitter with 1 watt Guard and 10 watts Trip outputs into a 60 ohm load. The single 10 watt output required for multi-station supervisory control can be obtained with various combinations of settings of R64 and R70., but in case repairs have made readjustment necessary the following procedure is preferred. 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. Connect a short clip lead across R71 so that Q55 will be kept non-conductive. Turn power controls R64 and R70 to minimum (full counterclockwise). 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.

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

Remove the lead that was connected across R71 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 load resistor, and reconnect the coaxial cable circuit to the transmitter.

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 2.2 megacycles 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 a minor adjustment of the output frequency should be needed, this can be made with capacitor C53.

MAINTENANCE

Periodic checks of the transmitter power output 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 10 Watts Output
TP52	20
TP53	5.4
TP54	3.4
TP55	18.5
TP56	18.5
TP57	<1
TP58	45
TP59	<1
TP101	0
TP103	21 ± 2
TP105	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 voltages read with a-c VTVM.

Test Point	Voltage at 10 Watts Output	Test Point	Voltage at 10 Watts Output
TP54 to TP51	0.015 – 0.03	T2-1 to Gnd.	1.85
TP57 to TP51	0.3 – 1.2	TP101 to TP103	17.0
		TP103 to TP105	17.0
TP59 to TP51	0.3 – 1.2		
		T3-4 to Gnd.	112
T1-1 to TP51	5.6	T4-2 to Gnd.	110
T1-3 to TP51	4.9	TP109 to Gnd.	31
T1-4 to Gnd.	2.0	J102 to Gnd.	24.5

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 cycles/ sec. to 230-kc.; 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-kc to 230-kc

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.

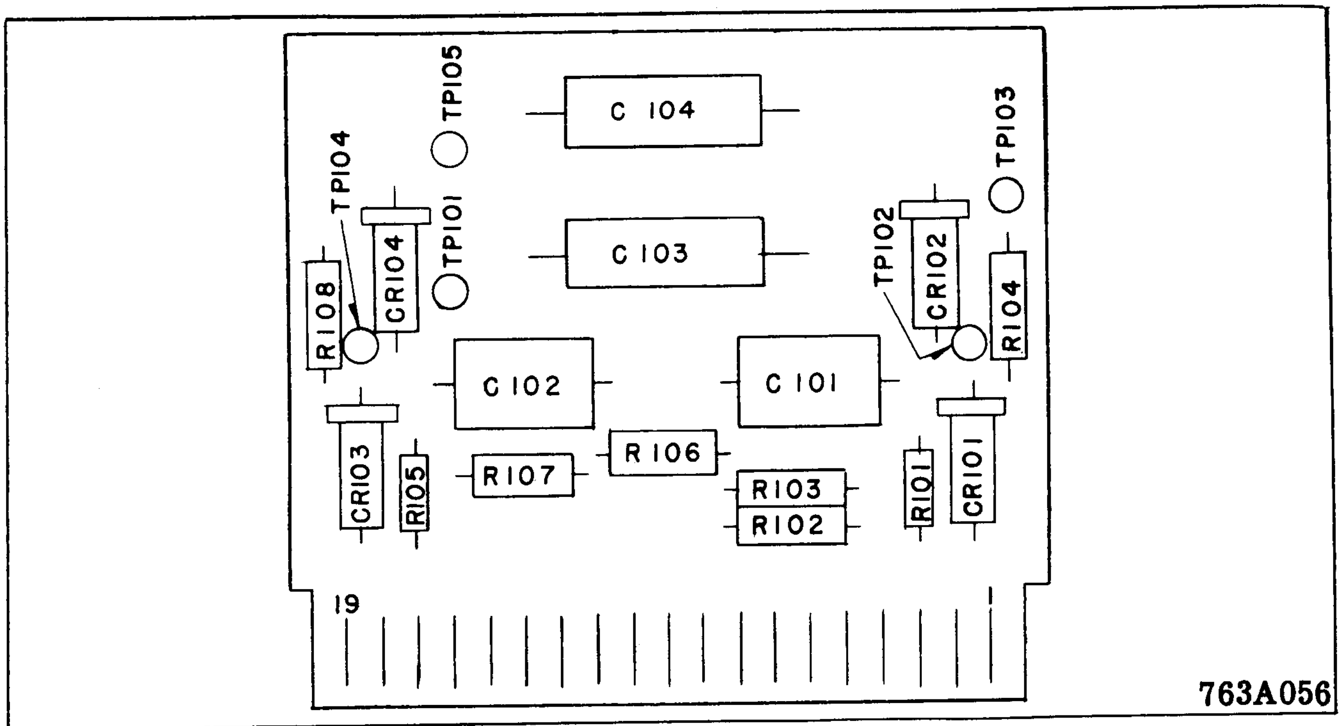

Fig. 4 Component locations of the Power Amplifier printed circuit board.

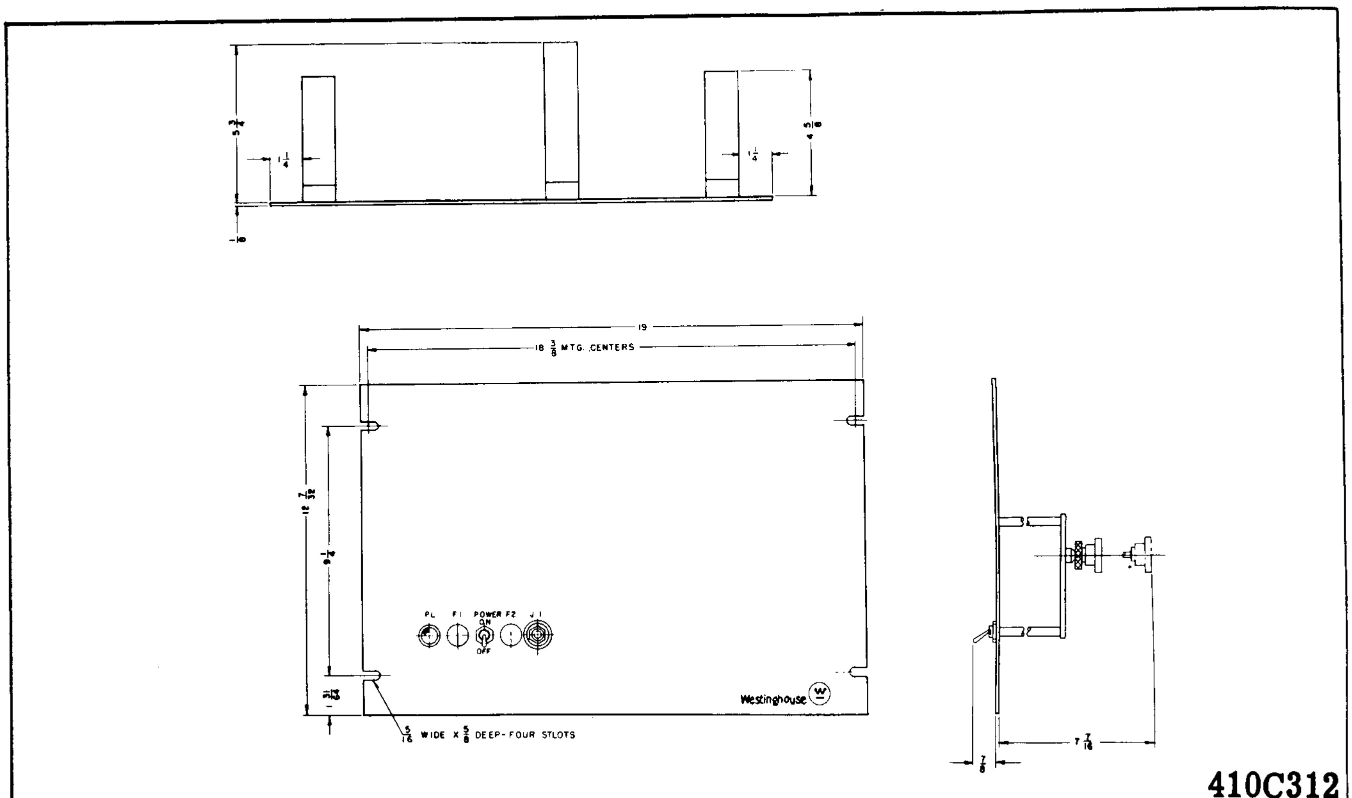

Fig. 5 Outline and drilling plan for the type TCF transmitter assembly.

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