Command Set Audio Transformers

March 6, 2026 N4LG

Specifications:

The SCR-274-N and related Command Sets used several different audio output T1 transformers to match varying headset standards of the time.

ES-691027: This is a standard Western Electric part number often found in the SCR-274-N series (e.g., BC-453-A, BC-454-A, BC-455-A). It is designed for high-impedance headsets, typically providing an output of 4,000 Ω.

5631: Often found in early Army Air Force production units, this T1 transformer is functionally similar to the ES-691027, primarily intended for the high-impedance (4,000 Ω) output standard required by early Army aircraft intercoms.

40838: This part number is associated with the Navy ARA and AN/ARC-5 versions. Unlike the Army versions, Navy headsets used a lower impedance standard, and this T1 transformer provides an output impedance of 300 to 600 Ω.

6308: This is a dual-tap or later-version T1 transformer found in later SCR-274-N series (e.g., BC-453-B, BC-454-B, BC-455-B). It was designed for increased compatibility, featuring a 250 Ω tap in addition to the standard high-impedance winding, allowing the receiver to be used with newer low-impedance headsets by moving from T1 terminal-3 to T1 terminal-6.

Key Differences Summary

The following table summarizes the primary electrical differences between these components:

Part Number	Primary Use	Output Impedance	Series Compatibility
ES-691027	Standard Army	4,000 Ω	SCR-274-N (Standard)
5631	Early Army	4,000 Ω	SCR-274-N (Early)
40838	Navy / ARC-5	300 - 600 Ω	ARA, AN/ARC-5
6308	Multi-tap Army	250 / 4,000 Ω	SCR-274-N (-B and later)

Functional Summary

ES-691027 & 5631: Standard 4-pin configuration for 4,000-ohm Army headsets.
40838: Used in Navy/ARC-5 units with a lower secondary winding turns ratio to match 300–600 ohm headsets.
6308: A 5-pin variant allowing a switchable output impedance

DC Resistance Values

For most Command Set receivers (BC-453, BC-454, BC-455), the output transformer typically matches the following resistance profiles:

Primary Winding (Plate to B+), 350 to 500Ω DC. This winding connects the plate of the 12A6 output tube to the high-voltage supply (B+).

Secondary Winding (Headset Output), High-Impedance (**ES-691027, 5631**): Approximately 200 to 300 ΩDC. These are designed to drive 4,000Ω headsets.

Low-Impedance (**40838**): ~25 to 50Ω DC. These are for the Navy-style 300–600 Ω headsets.

Multi-tap (**6308**): You will find two distinct readings. The full winding (high-Z) will be ~250Ω DC, while the tap (low-Z) will measure significantly lower, often ~40Ω DC.

How to Identify Terminals on the Transformer
If your transformer is removed from the chassis and the pins are not clearly marked, you can identify them using a multimeter. Primary is the two pins with the highest resistance (typically 350–500Ω). Secondary is the remaining pins will show lower resistance. For **ES-691027/5631**, the secondary resistance is usually ~200–250Ω. For **40838**, the secondary resistance is much lower, typically ~30–50Ω. There should be no continuity between the primary pins and the secondary pins. If you measure any resistance between Pin 1 and Pin 3, the transformer has an internal short.

Transformer Pin Connection Diagram
Below is the standard wiring configuration for these transformers:

Primary Side (High Voltage/Tube Side)
Pin 1: Connects to the Plate of the 12A6 output tube.
Pin 2: Connects to the B+ (250V) supply (typically through the screen grid circuit).

Secondary Side (Audio/Headset Side)
Pin 3: Ground (Common). Connects directly to the receiver chassis.
Pin 4: Audio Output (High-Z). This is the main output for standard headsets (found on all models: **ES-691027, 5631, 40838, and 6308**).
Pin 5 (**6308 only**): Low-Impedance Tap. Present only on the **6308** multi-tap version to provide a ~250 Ω output.

Physical Pin Layout
While the internal schematic is standard, the physical location of the pins on the transformer "can" varies by manufacturer. Use a multimeter to confirm the pins based on DC Resistance.

Transformer Section	Pin Connection	Expected DCR (approx.)
Primary	Pin 1 to Pin 2	350 – 500 Ω
Secondary (High-Z)	Pin 3 to Pin 4	200 – 300 Ω (**ES-691027, 5631**)
Secondary (Low-Z)	Pin 3 to Pin 4	25 – 50 Ω (**Navy 40838)**

Secondary (Tap)	Pin 3 to Pin 5	~40 Ω (**6308 Only**)

Internal Wiring Differences by Part Number
The primary difference is which internal winding is connected to the output pins:

Part Number	Pin 1-2 (Primary)	Pin 3-4 (Secondary)	Pin 5 (Secondary)
ES-691027	Plate to B+ (~450Ω)	4,000Ω Output	N/A
5631	Plate to B+ (~450Ω)	4,000Ω Output	N/A
40838	Plate to B+ (~450Ω)	300-600Ω Output	N/A
6308	Plate to B+ (~450Ω)	4,000Ω Output	250Ω Tap

Standard 12A6 Output Stage Tube Layout

12A6 Tube Pin	Connection Point	Transformer Pin
Pin 3 (Plate)		Pin 1 Output Transformer Primary (Start)
Pin 4 (Screen)		B+ Rail
Pin 8 (Cathode)		Self-biased via resistor and capacitor to GND

Transformer & 12A6 Integration

Primary Winding (High Resistance):
Pin 1 (Plate): Connects to Pin 3 of the 12A6 tube. This is the "start" of the primary winding.
Pin 2 (B+): Connects to the 250V DC power supply rail. This provides the operating voltage to the 12A6 plate through the transformer.

Secondary Winding (Low Resistance):
Pin 3 (Common): Connected to Chassis Ground.
Pin 4 (High-Z Output): Audio Output terminal (Pin 5 of the rear 6-pin chassis connector).
Pin 5 (Low-Z Tap): Only on the **6308** model a low-impedance (250-ohm) alternative.

Rear Connector Pinout (BC-Models)
To test the audio output of an SCR-274-N receiver (BC-453, BC-454, or BC-455) from the outside, use the 6-pin male connector located at the rear of the chassis. The pins are typically numbered on the connector or the chassis. When looking at the rear of the receiver (the plug on the radio itself):

Pin 1: Ground (Chassis).
Pin 2: LV Filaments (Connects to 24–28V DC [+] for tube heaters).
Pin 3: Gain/Volume Control (Connects to the center tap of the external 50kΩ volume potentiometer in the control box).
Pin 4: B+ High Voltage (Input for 250V DC from the dynamotor or external power supply).
Pin 5: Audio Output (TEL). Secondary of the **ES-691027, 5631, 40838,** or **6308** transformers.

Pin 6: CW/MCW Switch (Connects to the BFO switch on the remote control box).

Testing Transformers
Testing the transformers involves measuring the DC resistance (DCR) of the primary and secondary windings to ensure there are no opens or shorts. Because these are vintage components, minor variations from "factory" specs are normal due to aging or different manufacturers (e.g., Western Electric vs. Colonial).

Testing Benchmarks
Ensure there is no continuity between the primary side (Pins 1 & 2) and the secondary side (Pins 3 & 4). Any measurable resistance here indicates an internal short. Measure between any pin and the metal transformer case. This should be an open circuit. Verify the impedance by applying a low AC voltage (e.g., 10V AC) to the primary and measuring the secondary output. For a 4,000-ohm unit, the voltage will step down significantly.

Testing Procedure
Use a Multimeter set to the Ohms (Ω) scale. Measure across the primary leads and then the secondary leads. If either reads infinite, the transformer is "open." Measure between any lead and the transformer's metal casing/frame. This should read Infinite (Open). Any measurable resistance indicates an internal short to the core.

Turns Ratio Test: For more advanced verification, apply a small AC voltage (e.g., 5V AC) to the primary and measure the output on the secondary. The ratio of voltages is equal to the turn's ratio in a transformer. The impedance ratio (Z1/Z2) is equal to the square of the turns ratio (N1/N2) or the same as the square of the voltage ratio (V1/V2).

Insulation resistance test: tests insulation between windings and ground done using a megohmmeter (megger).

How to Test the Transformer Internally via the Plug
You can verify the health of the output transformer using a multimeter on the Ohms (Ω) setting without opening the case:

Test the Secondary Winding: Measure between Pin 5 (Audio) and Pin 1 (Ground).
For High-Impedance (ES-691027/5631): You should see ~200–300Ω.
For Low-Impedance (40838): You should see ~25–50Ω.

Test the Primary Winding: Measure between Pin 4 (B+) and Pin 3 of the 12A6 tube (this requires opening the top) OR measure between Pin 4 (B+) and the Plate circuit.

Note: If you cannot open the case, you cannot easily test the primary from the rear plug alone, as the primary is isolated from the external pins by the 12A6 tube's plate

Quick Audio Verification
To hear if the transformer and audio stage are working, connect a high-impedance headset (or a speaker with a matching transformer) between Pin 5 and Pin 1. With power applied, you should hear a "click" in the headset when you touch the probes or power the unit on, indicating continuity through the transformer. Warning: Pin 4 carries 250V DC when the unit is powered. Always ensure the power is off and capacitors are discharged before performing resistance tests on these pins

Transformer Replacement
Replacing the original (**ES-691027, 5631, 40838, 6308**) output transformers in SCR-274-N (BC-453, BC-454, or BC-455) receivers require a transformer that can handle the high-plate impedance of the 12A6 tube (~7,500–8,000 Ω) and match it to the desired output, such as a modern 8 Ω speaker or a 600 Ω line. A replacement audio output transformer with a 4,000-6000 Ω primary is a "safe mismatch" for higher volume at the cost of slightly higher distortion. Using a 4,000-6000Ω transformer will work but may cause the 12A6 to run hotter. The transformer must handle at least 20–30mA of DC plate current without saturating the core.

Most modern replacements use wire leads rather than the original 4-pin or 5-pin solder terminals found on the vintage "can" style transformers. You will likely need to mount the new transformer inside the chassis or on a custom bracket and solder the leads directly to the 12A6 tube socket and the rear output jack.

Reduce Audio Hum and Noise
Vintage military receivers often suffer from "hum" due to original grounding practices that aren't ideal for sensitive modern speakers.

Create a Ground Bus: Instead of using various chassis screws as ground points, move the tube heater (filament) grounds to a single, dedicated ground bus wire. Connect this bus to the chassis at a single point near where the main power enters the radio to significantly reduce background hum.

Replace Old Capacitors: If you haven't already, "recap" the unit by replacing original paper or electrolytic capacitors with modern equivalents. Pay special attention to the audio coupling capacitor between the 12SR7 detector and the 12A6 output tube; a leaky capacitor here will cause distortion and can damage your new transformer.

Optimize Gain and Fidelity
Modern speakers are much more efficient than original military headsets, which can make the audio feel "too hot" or easily overdriven. Some improved versions of these receivers (like the R-23A) used a 1k ohm cathode resistor on the 12A6 instead of the standard 1.5k ohm to increase audio power output. If the audio is weak, lowering this resistance can boost gain, though it may increase heat. If you are using a modern AC power supply instead of the original

dynamotor, ensure the B+ voltage is well-filtered and regulated. Fluctuations in the high-voltage rail directly affect the audio clarity of the output stage

Simple Treble-Cut Circuit
The most effective way to do this is by adding a potentiometer and a capacitor in series between the grid of the 12A6 and ground. This forms a variable RC low-pass filter. The recommended component values are a 50k-100kΩ log potentiometer and chosen mylar or polypropylene capacitor. The possible choices are 0.01µF for subtle roll-off removing the "hiss" without muffling voices, 0.022µF for a good range from "bright" to "mellow", or 0.047µFfor deep roll-off where you only want to hear low-frequency voice peaks.

Locate 12A6 Pin 5 (Control Grid) where the audio signal enters the AF tube. Solder one leg of your chosen capacitor to Pin 5 of the 12A6 socket. Connect the other leg of the capacitor to the center terminal (wiper) of the tone control pot, and connect one of the outer terminals of the pot to the chassis ground.

Alternate: Fixed "Anti-Hiss" Capacitor
If you don't want to mount an extra knob on the front panel, you can simply solder a small fixed capacitor (between 250pF and 500pF) directly from Pin 5 of the 12A6 to Ground. This acts as a permanent "snubber" that removes high-frequency RF noise and sharp hiss without significantly affecting the voice audio quality.

NFB Circuit Design
Adding a Negative Feedback (NFB) loop is the single best way to "hi-fi" a Command Set. It flattens the frequency response, reduces the "pentode harshness" of the 12A6, and lowers the output impedance for better speaker damping. You will loop a small portion of the audio from the transformer secondary back to the 12A6 driver stage (the 12SR7 or 12SF7). The required components are a feedback resistor 10-22kΩ 1/2 watt and a 0.1uF 100V blocking capacitor. The options are using lower feedback resistance for cleaner but quieter output, or higher feedback resistance for more output with higher harmonic distortion.

Connect one side of the RC series pair to the hot side of your new transformer secondary, the side going to Pin 5 of the rear plug. And, connect the other side of the RC series pair to the Control Grid (Pin 5) of the 12A6. If your receiver uses a 12SR7 driver, you can also inject the feedback into the grid of that tube for even higher global feedback.

Check NFB Phase: If the radio howls or squeals like a siren when you turn it on, the feedback is "Positive" instead of "Negative." Swap the two primary wires (Blue and Red/Brown) on the transformer. This reverses the phase and turns the squeal into clean audio. The expected results are tighter bass, lower noise floor, and slightly less audio, but significantly more "linear."

Cathode Bias Change
To keep the 12A6 tube running cooler—especially when using modern power supplies that often run a bit higher than the original 24V/250V dynamotor specs—you should increase the cathode bias resistor.

In the original SCR-274-N design, the cathode resistor is typically 380 to 450 ohms (depending on the specific BC-series production run). This biased the tube for maximum military-grade "punch," which often pushed the 12A6 to its thermal limits.

To shift the tube into a "cooler" Class A operating point that extends tube life and plays better with a Negative Feedback (NFB) loop, change cathode resistor to a 560-620Ω, 2-5W wirewound, and change the cathode bypass capacitor to a 22-47µF rated for 50V. Using a larger capacitor here will significantly improve the bass response into your 8-ohm speaker compared to the original small-value military caps.

Locate Pin 8 (Cathode) of the 12A6 socket. Remove the ***original 400Ω*** resistor and the old bypass capacitor. Solder the **new 620Ω** resistor and the **47µF** capacitor in parallel from Pin 8 to ground. Ensure the positive (+) side goes to Pin 8.

Increasing the resistance increases the negative bias on the control grid relative to the cathode and *lowers the idle plate current*. The original circuit drew ~25-30mA at idle, running the tube "hot". Now it draws ~18-22mA at idle and the tube runs significantly cooler, the transformer core is less likely to saturate (giving you cleaner audio), and the 12A6 will last for decades of hobby use.

Confirm your 12A6 is running in the "sweet spot" with your new cathode resistor, you can calculate the plate current using Ohm's Law (I=V/R). Measure: DC voltage on Pin 8 of the 12A6 socket. You should see a reading between 11V and 15V DC. If you measure 13.5V across a 620Ω resistor I=V/R=13.5/620 = 0.0217A or 21.7mA. This is a perfect "cool" operating point for a long-lived 12A6.

Safety Check the Plate Dissipation - To ensure you aren't exceeding the tube's 8.5-watt limit, multiply your B+ voltage (Pin 4) by the current you just calculated. Example: 250VDC x 0.022A = 5.5W. Since 5.5W is well below the limit, your tube will run reliably for years without overheating your new transformer.

Troubleshooting the Reading - If voltage is too high (>18V): The tube is drawing too much current. Check for a leaky coupling capacitor on Pin 5 (Grid) which might be "pulling" the grid positive. Voltage is too low (<8V), the tube is "weak" or "gassy" and should be replaced, or your B+ supply is under-voltage.

EXERPTS FROM MAINTENANCE MANUALS

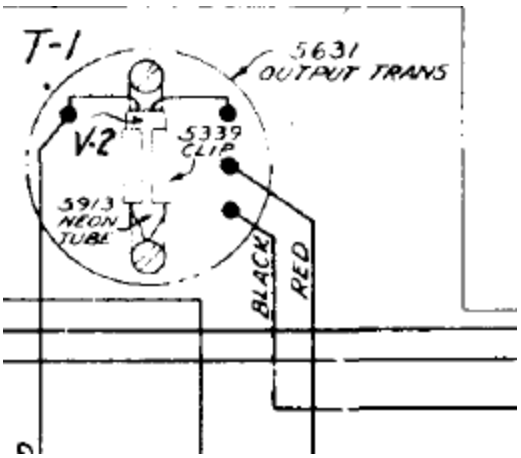
BC-xxx-A: T1 (output transformer) is high impedance only.
BC-xxx-B: T1 has both high and low impedance taps; set at factory for high-z.
BC-xxx-C: T1 (unknown differences).
BC-xxx-D: T1 (unknown differences).
BC-xxx-E: T1 has high/low taps; set at factory for low-z.

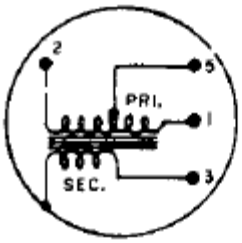
Transformer Data from TO-12R2-3SCR274-2

Primary, 4000 turns #40 enamelled wire, d-c resistance 1028-1300 ohms (terminals 1-2), center-tapped (terminal 5). Secondary, 1800 turns #38 enamelled wire, d-c resistance 292-370 ohms (terminal 3-case)	Receiver output	6308
Primary, 4000 turns #40 enamelled wire, d-c resistance 1028-1300 ohms (terminals 1-2), center-tapped (terminal 5). Secondary, 1800 turns #38 enamelled wire, d-c resistance 292-370 ohms (terminal 3-case), secondary tapped (terminal 6), 1325 turns, d-c resistance 86-110 ohms (terminal 6-case)	Receiver output	ES-691027

ARC-5 R23, R24, R25, R26, R27

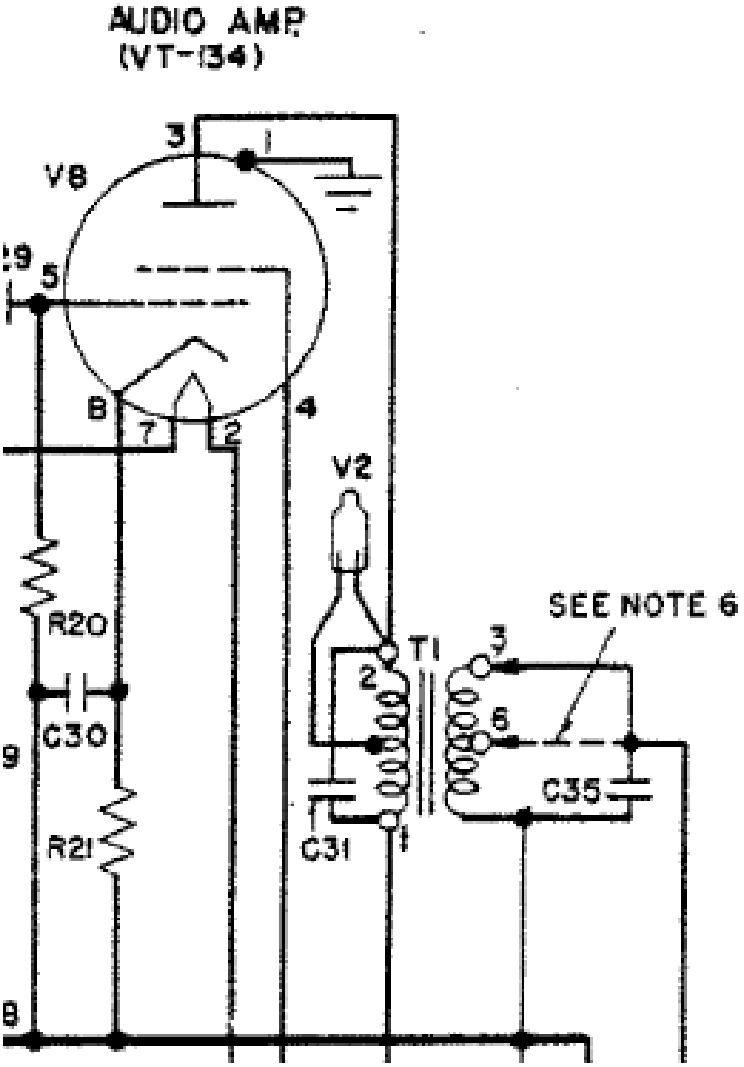
T-1	R16T6435	TRANSFORMER, AF, Plate coupling type, turns ratio 8 to 1, primary turns d-c resistance 1160 ohms ± 15%, secondary turns d-c resistance 26 ohms ± 15%	Audio output to receiver	ARC-5631 STC-640268





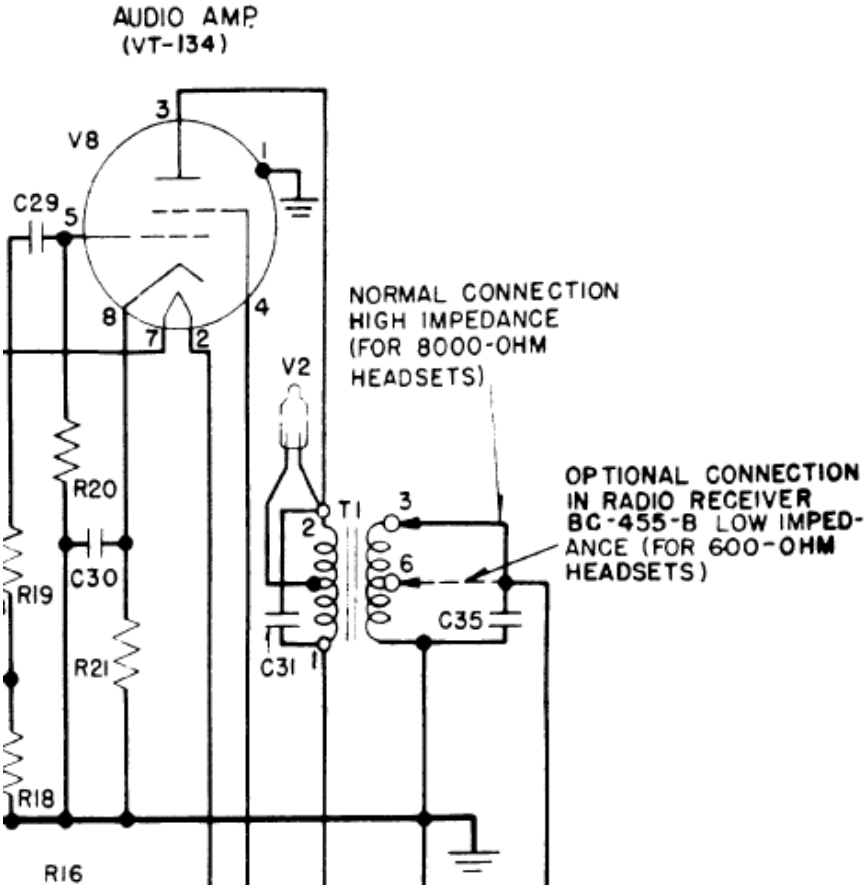
SYMBOL T-1
OUTPUT
TRANSFORMER

BC-453-A



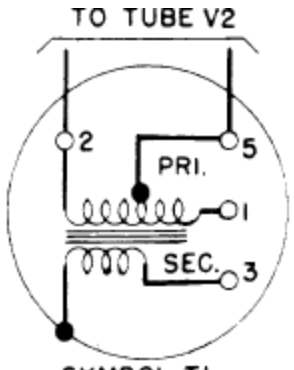
6. TRANSFORMER T1 IN BC-453-B, BC-454-B AND BC-455-B RECEIVERS IS PROVIDED WITH A TAP (TERM.6) FOR LOW IMPEDANCE HEADSETS. THESE THREE RECEIVERS AND RADIO RECEIVERS BC-453-A, BC-454-A AND BC-455-A ARE NORMALLY FURNISHED WITH CONNECTION SHOWN IN SOLID LINES FOR USE WITH HIGH IMPEDANCE (8000 OHMS) HEADSETS. RADIO RECEIVERS BC-453-B, BC-454-B, AND BC-455-B CAN BE CHANGED FOR USE WITH LOW IMPEDANCE HEADSETS BY REMOVING THE TWO WIRES ON TERMINAL 3 AND CONNECTING THEM TO TERMINAL 6 AS SHOWN IN DASHED LINES. (SEE FIGURE 39)

BC-455-A/B

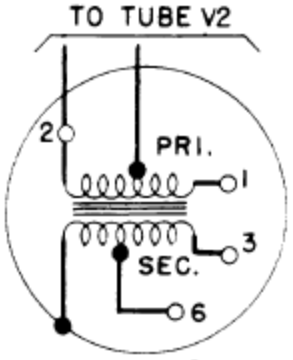


C-31, across the primary of T-1, assists C-35, across the secondary, in reducing the output of high audio frequencies. The design of transformer T-1 is such that the leakage reactance, with the aid of C-31 and C-35, attenuates frequencies above 3000 cycles per second.

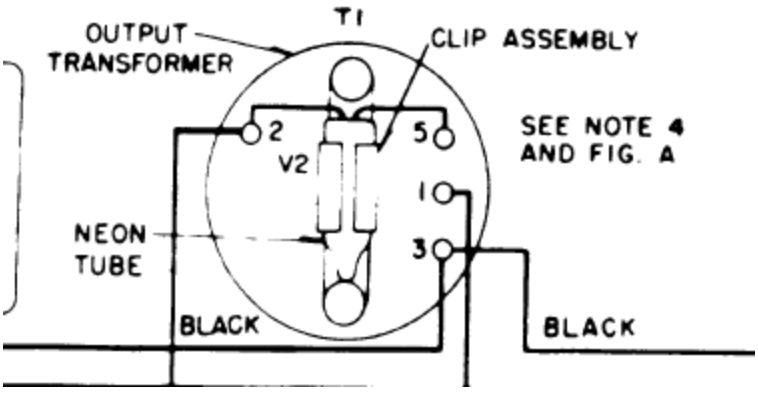
V-2 is a small neon lamp acting to protect the equipment when exceptionally strong signals are received. This lamp glow at approximately 80 volts. As soon as the glow starts, any increase in voltage across the lamp terminals causes a relatively large increase in current. In this manner, the voltage is limited to 80 volts across half of the primary winding of T-1.



SYMBOL T1
OUTPUT TRANSFORMER
RADIO RECEIVER BC-455-A



SYMBOL T1
OUTPUT TRANSFORMER
RADIO RECEIVER BC-455-B



4. RADIO RECEIVER BC-453-B IS EQUIPPED WITH OUTPUT TRANSFORMER ES-691027 TO PERMIT USE OF 600-OHM HEADSETS BY REWIRING AS SHOWN IN FIG. A.

ES-691027
OUTPUT TRANSFORMER

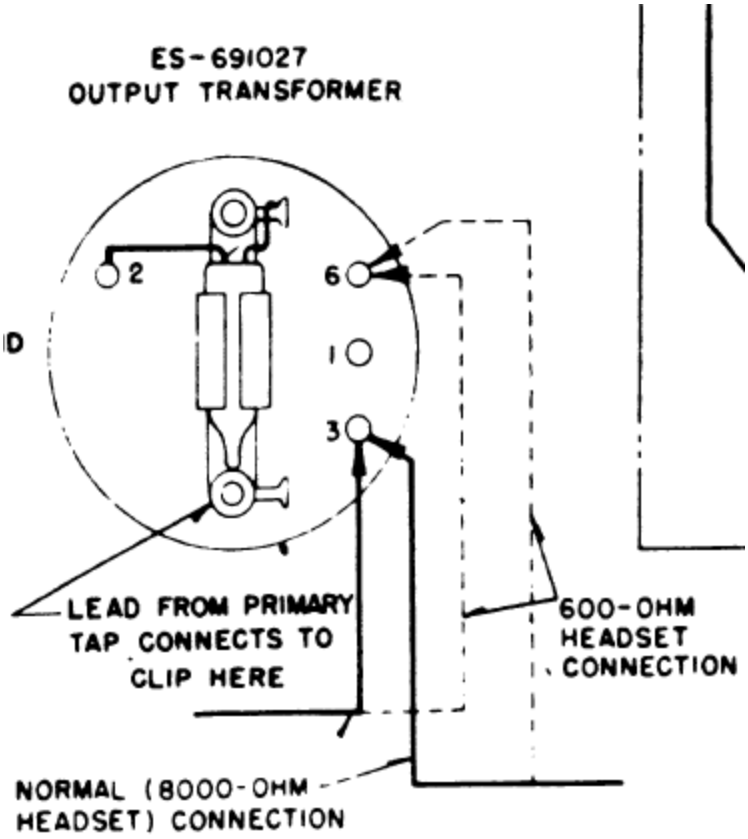
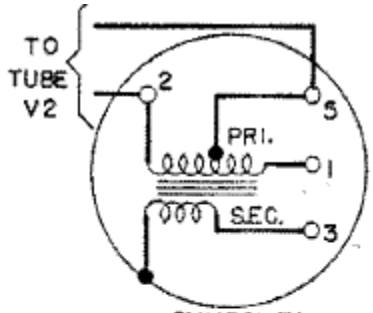
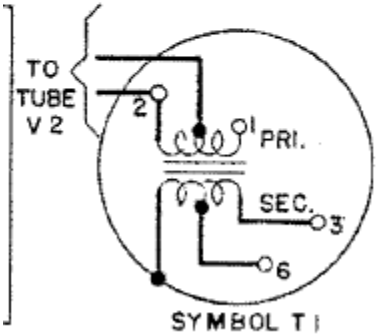


FIG. A



SYMBOL T1
OUTPUT TRANSFORMER
RADIO RECEIVER BC-453-A



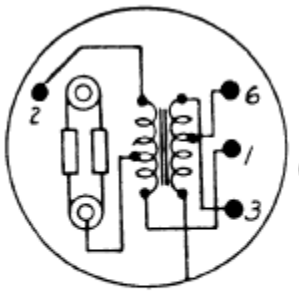
SYMBOL T1
OUTPUT TRANSFORMER
RADIO RECEIVER BC-453-B

(12) V-1 and V-2 are small neon lamps acting to protect the equipment when exceptionally strong signals are received. These lamps glow at approximately 80 volts. As soon as the glow starts, any increase in voltage across the lamp terminals causes a relatively large increase in current. In this manner, the voltage is limited to 80 volts across L-1 and likewise across half of the primary winding of T-1.

T-1	2Z9947-4.1	Transformer	Primary, 4000 turns #40 E. wire, secondary, 1800 turns #38 E. wire, primary d-c resistance 1028-1300 ohms, secondary d-c resistance 272-350 ohms.	Rec. output.	K	ESL691027

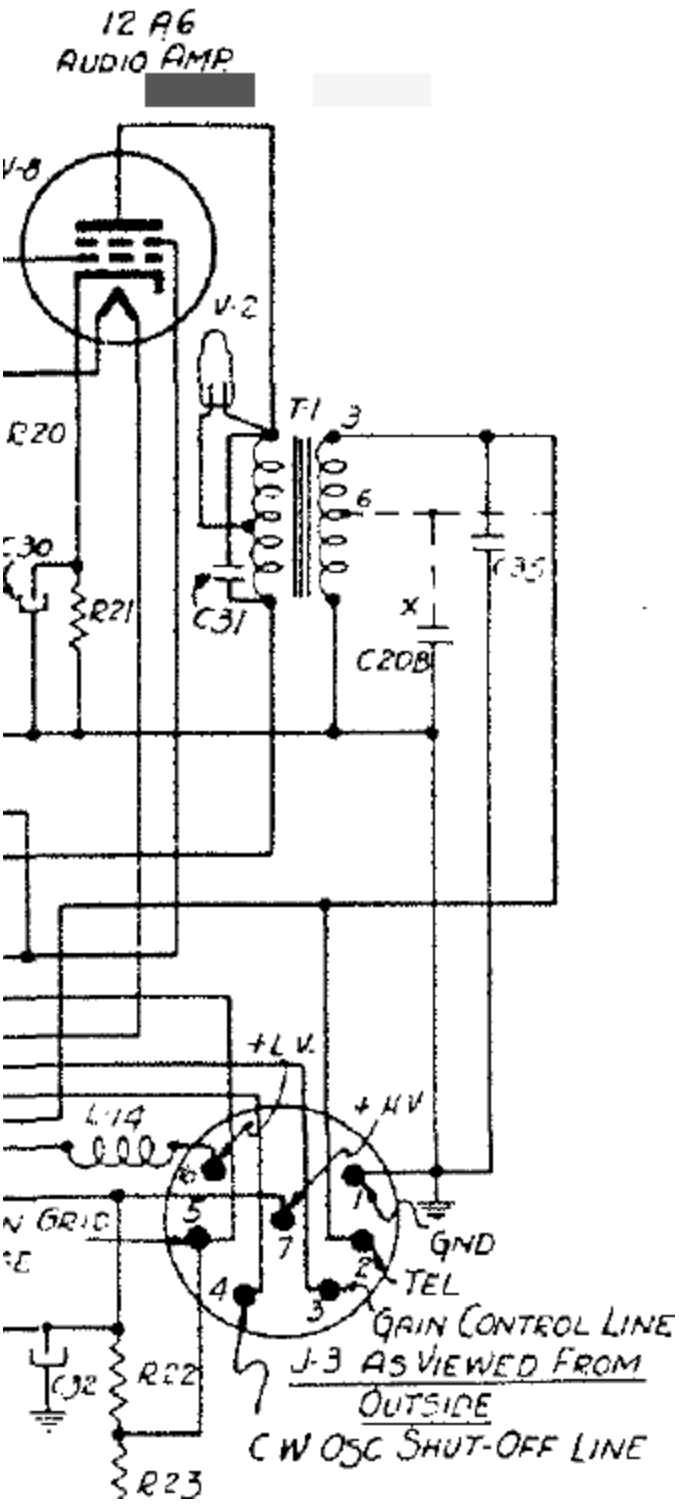
BC-946-B

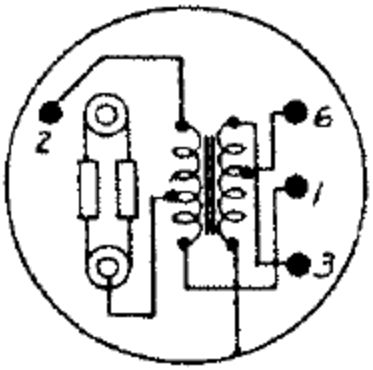
OUTPUT IMPEDANCE
To change from a 4,000 ohm output connection to 300 ohm, on RADIO RECEIVER BC-946-B:
(1) Remove capacitor C35
(2) Disconnect the black lead from terminal 3 on output transformer T-1 and connect it to terminal 6
(3) Connect a new lead from X on C20B to terminal 6 on output transformer, or to the same terminal from which C35 was disconnected on the power plug.



SYMBOL T-1
OUTPUT TRANSFORMER

④
C 35 & TERMINAL 3 TO BE USED FOR 4000 OHM OUTPUT
C 20B & TERMINAL 6 TO BE USED FOR 300 OHM OUTPUT


12 A6
AUDIO AMP
V-2
T-1
3
6
R20
C30
R21
C31
X
C20B
C35
+L.V.
+H.V.
L-14
GND
TEL
GAIN CONTROL LINE
J-3 AS VIEWED FROM
OUTSIDE
C W OSC SHUT-OFF LINE
C32
R22
R23



SYMBOL T-1
OUTPUT TRANSFORMER

④
C35 & TERMINAL 3 TO BE USED FOR 4000 OHM OUTPUT
C208 & TERMINAL 6 TO BE USED FOR 300 OHM OUTPUT

C-20(A,B,C)	05/01/.05 MFD
C-21	17 MMF
C-22	180 MMF
C-23	180 MMF
C-24	200 MMF
C-25	.001 MFD
C-26	100 MMF
C-27	335 MMF
C-28	34 MMF
C-29	.006 MFD
C-30	15 MFD
C-31	.001 MFD
C-32	5 MFD
C-33	WIRING CAPACITANCE LESS THAN 2 MMF
C-35	750 MMFD (SEE NOTE ④ BELOW)