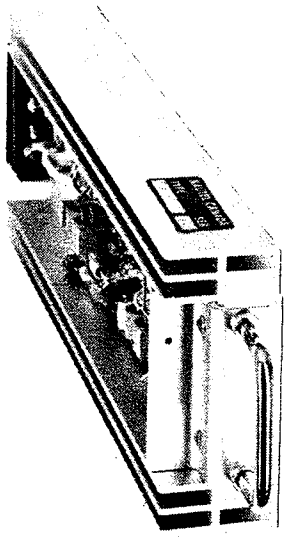
SERVICE INSTRUCTION

NAA11

POWER AMPLIFIER MODULE



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LIST OF EFFECTIVE PAGES

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INTRODUCTION

1. The NAA11 power amplifier module is a class D, switched mode, rf power amplifier that is used in Nautel's AMPFET series of transmitters. Troubleshooting and repair of the module is performed on a work bench independent of it's associated transmitter. This document provides the information required for a competent technician to understand the operation of the electrical circuits and the the procedures to restore defective modules to a serviceable status; using tools and test equipment normally available at an AM radio station workshop. An alternative to procedures provided in this document is to utilize Nautel's module exchange/repair service facilities.

FACTORY EXCHANGE/REPAIR SERVICE

2. Nautel provides a factory, module exchange/repair service for users of Nautel's AMPFET series of transmitters. Users who do not have repair facilities or who are not able to repair a module may utilize this service for a nominal fee.

MECHANICAL CONFIGURATION

3. The NAA11 power amplifier utilizes an extruded, finned, heat sink as the module chassis. The electrical components are mounted directly on the heat sink to ensure optimum heat dissipation from the eight power MOSFET's. An electrical connector is installed on the rear of the heat sink and a stamped panel containing a handle and a test point is installed on the front. Three variations in the method of connecting the output of the power MOSFETs to the output transformer are in use, but they are all electrically identical and fully interchangeable. Refer to figure 2 (A, B and C) for the assembly detail of a specific variation.

THEORY OF OPERATION (refer to figure 1)

4. The NAA11 power amplifier module is a class D, switched mode, rf power amplifier which is capable of providing 250 Watts of carrier power with a 100 percent amplitude modulated waveform over an rf frequency range of 0.5 MHz to 2.0 MHz.

4.1 The 'rf drive', which is a 36 volt peak-to-peak signal at the carrier frequency, is applied to the primary windings of transformers T1 and T2. T1 and T2 are 3:2 stepdown transformers that each have four sets of identical secondary windings. One end of each winding is connected to the gate and the other end is connected to the source of a power MOSFET. The power MOSFET's associated with each transformer are connected in a series push-pull arrangement with the phasing of their inputs determining which pair of power MOSFET's are turned on. The outputs of the power MOSFET's associated with each transformer are connected in parallel. Since these circuits are identical, the description for the circuit associated with transformer T1 is also applicable to the circuit associated with transformer T2.

4.2 When the gate of power MOSFET Q1 goes positive, the gate of power MOSFET Q6 also goes positive, while the gates of power MOSFETs Q2 and Q5 will go negative. Q2 and Q5 will be turned off and Q1 and Q6 will turn on, causing current to flow from ground, thru the source/drain junction of Q6, thru the primary of transformer T3, thru the source/drain junction of Q1 to the '-DCV' modulation drive voltage source. During the next half cycle, the gates of power MOSFET's Q2 and Q5 will go positive and the gates of power MOSFET's Q1 and Q6 will go negative. Q1 and Q6 will be turned off and Q2 and Q5 will turn on, causing current to flow from ground, thru the source/drain junction of Q2, thru the primary of transformer T3 (in the reverse direction), thru the source/drain junction of Q5 to the '-DCV' modulation drive voltage source. The 'rf output', on the secondary of transformer T3 is essentially a square wave at the rf carrier frequency. In use, this square wave is externally filtered into a sine wave.

4.3 The magnitude of the current flow thru the primary of transformer T3 and therefore the 'rf output' level, is dependent on the amplitude of the '-DCV' modulation drive voltage source. When there is no modulation present, this voltage is a fixed negative dc voltage that is set externally to provide the desired 'rf output' level. When modulation is present, the modulation waveform is superimposed on the '-DCV' modulation drive voltage and it is increased and decreased at the rate of the modulating signal's waveform.

4.4 Zener diode CR1 ensures the '-DCV' modulation drive voltage is not permitted to exceed -75 volts. Diodes CR2 thru CR9 protect power MOSFET's Q1 thru Q8 from voltage transients.

4.5 When a NAA11 power amplifier is installed in an AMPFET transmitter, its rf output is connected in series with a number of other power amplifiers. If the '-DCV' modulation drive signal is removed from a power amplifier, its power MOSFETS will not contribute to the rf output of the transmitter, but their substrate diodes will act as back-to-back diodes and reflect a low impedance (effectively a short circuit at the carrier frequency) to the secondary of transformer T3. This low impedance ensures the output of the remaining power amplifiers, in the series string, is not affected by the loss of a power amplifier and they will continue to contribute their share of the transmitters rf output. The transmitter will continue to operate at a reduced power level.

FUNCTIONAL TEST

5. Functional testing of a NAA11 power amplifier on a work bench requires specialized test equipment not normally available outside of the factory. The only practical method of functionally testing a power amplifier in the field is to install it in an AMPFET transmitter and verify it is contributing to the transmitters rf output. AMPFET transmitters have PA fault detection circuits incorporated into their design that will automatically turn off any power amplifier which is not contributing its share to the transmitter's rf output.

CAUTION

Observe the operating precautions noted in section 4 of the AMPFET transmitter's instruction manual when removing NAA11 power amplifiers from a transmitter. Damage to mating connectors or destruction of solid state devices may result if a power amplifier is removed when the transmitter is turned on.

TROUBLESHOOTING

6. Trouble shooting of the NAA11 power amplifier consists of visual inspection and resistance measurements. Isolate a defective component or fault in the assembly as follows:

6.1 VISUAL INSPECTION: Perform the following visual inspections:

(a) Inspect transformers T1 thru T3, capacitors C1 thru C4, and diodes CR1 thru CR9 for evidence of overheating or physical damage.

(b) Inspect all solder connections for good mechanical bond and adequate solder.

(c) Verify connector P1 does not contain damaged or loose pins and that it is securely fastened to its bracket.

(d) Verify all wiring insulation is intact and is not frayed, broken or otherwise damaged.

(e) Verify wiring conductors are not pinched or damaged and they do not contain broken wire strands.

(f) Verify all leads of power MOSFET's, which protrude thru the heat sink, are not shorting to the heat sink and the protective plastic sleeve over the gate leads of Q1 thru Q8 and the source leads of Q2, Q4, Q6 and Q8 is present and is not damaged.

(g) Verify a plastic sleeve is installed on the screws located between the metal straps connecting the cases of power MOSFETs Q1, Q3, Q5 and Q7 to transformer T3 and the screws are not shorting to the straps. (Variation shown in figure 2C only)

(h) Verify the chassis is free from solder slivers and other conductive foreign objects; paying particular attention to the holes in the heat sink containing power MOSFET leads, the area around the insulated, conductive circuit board and under the straps connecting the drain and source gates of Q1/Q2, Q3/Q4, Q5/Q6 and Q7/Q8.

(i) Verify the insulation between power MOSFET's Q1, Q3, Q5, Q7 and the heat sink is not damaged and has been coated with thermal compound.

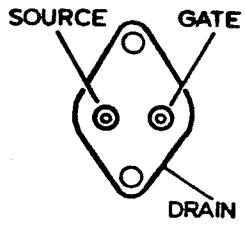
(j) Verify all fastening hardware is securely tightened.

6.2 RESISTANCE MEASUREMENT OF POWER MOSFETS: Isolate defective power MOSFET's by performing a resistance measurement of each device as follows:

NOTE
The power MOSFETS can be checked while still mechanically mounted on the heat sink provided their source and gate leads have been electrically isolated.

(a) Disconnect the wiring to the gate lead of each power MOSFET.

(b) Measure the resistance between gate and source using an ohmmeter. Resistance reading exceeds 20 megohms.



(c) Power MOSFETs that meet the requirements of step (b) are acceptable.

(d) Reconnect the wiring to the gate lead of each power MOSFET.

REPAIR

7. Replace any component or wiring which does not meet the requirements of the visual inspection, ensuring leads of replacement wiring and passive components, are kept to the shortest length possible without causing mechanical stress to component or lead.

7.1 POWER MOSFET REPLACEMENT: Replace any power MOSFET which does not meet the requirements of the resistance measurements as follows:

(a) Remove fastening hardware from the power MOSFET to be replaced.

(b) Disconnect the metal strap connecting the cases of power MOSFETs Q1, Q3, Q5 and Q7 to transformer T3 by removing the attaching screws from the under side of the heat sink, when Q1, Q3, Q5 or Q7 are to be replaced.

(c) Where necessary, disconnect strap between drain/source connections of Q1/Q2, Q3/Q4, Q5/Q6 and/or Q7/Q8 of power MOSFET to be replaced.

(d) Unsolder transformer T1/T2 lead from the gate lead of the power MOSFET to be replaced, ensuring solder is not splattered on the chassis.

(e) Unsolder source lead of power MOSFET's Q2, Q4, Q6 or Q8 from its connecting strap and then remove defective power MOSFET.

(f) Unsolder source lead of power MOSFET's Q1, Q3, Q5 or Q7 from the conductive surface of the circuit board, straighten the lead and then remove defective power MOSFET.

(g) Remove insulating tube from gate (all) and source (Q2, Q4, Q6 or Q8 only) leads of removed power MOSFET and install them on replacement power MOSFET.

(h) Apply a thin coat of thermal compound to both sides of insulator under replacement power MOSFET's Q1, Q3, Q5 or Q7; ensuring the thermal compound is free of foreign objects.

(i) Position insulator on heat sink where power MOSFETs Q1, Q3, Q5, or Q7 will be installed, ensuring lead and mounting holes are properly aligned.

(j) Remove the solder from the source lead hole in the connecting strap which was removed during removal of power MOSFET's Q2, Q4, Q6 or Q8.

(k) Place replacement power MOSFET in the appropriate position on the heat sink, ensuring insulator is installed between the device and the heat sink for power MOSFETs Q1, Q3, Q5, or Q7.

(l) Position insulating spacers in the mounting holes of power MOSFETs Q1, Q3, Q5 or Q7 from the under side of the heat sink.

(m) Install the drain/source connecting strap for power MOSFETs Q1/Q2, Q3/Q4, Q5/Q6 or Q7/Q8; ensuring the source lead of Q2, Q4, Q6 or Q8 extends thru the hole in the strap and the lugs attached to diodes (CR2 thru CR9) associated with the replacement power MOSFET are positioned over the appropriate mounting hole; and then secure using fastening hardware that was removed from defective power MOSFET.

(n) Solder the source lead of power MOSFET Q2, Q4, Q6 or Q8 to its connecting strap.

(o) Bend source leads of power MOSFET's Q1, Q3, Q5 or Q7 over the conducting surface of the circuit board, using needle nose pliers, ensuring the device is not damaged by mechanical stress and the lead is not shorted to the heat sink.

Table 1 Wiring Information - Transformer T1/T2

TRANSFORMER T1			TRANSFORMER T2		
LEAD COLOR	WINDING DIRECTION	DESTINATION	LEAD COLOR	WINDING DIRECTION	DESTINATION
Black	CW	RF Drive Terminal	Brown	CCW	RF Drive terminal
Black	CCW	Ground Lug	Brown	CW	Ground Lug
Blue	CW	Lug on Q1-Drain	Green	CCW	Lug on Q3-Drain
Blue	CCW	Q2-Gate	Green	CW	Q4-Gate
Violet	CW	Q1-Gate	Yellow	CCW	Q3-Gate
Violet	CCW	-DCV	Yellow	CW	-DCV
Grey	CW	Q6-Gate	Orange	CCW	Q8-Gate
Grey	CCW	Lug on Q5-Drain	Orange	CW	Lug on Q7-Drain
White	CW	-DCV	Red	CCW	-DCV
White	CCW	Q5-Gate	Red	CCW	Q7-Gate

NOTE: Winding directions are the direction when tracing the lead towards its end, as it leaves the transformer and the transformer is viewed from the top.

-DCV connections are made to the conducting surface of the circuit board

(p) Solder the source lead of power MOSFET Q1, Q3, Q5 or Q7 to the conducting surface of the circuit board.

(q) Solder the appropriate winding of transformer T1/T2 to the gate lead of the power MOSFET. Refer to table 1 for wiring information.

(r) Perform a visual inspection as outlined in paragraph 6.1.

7.2 TRANSFORMER T1/T2 REPLACEMENT: Replace defective rf drive transformers T1 and/or T2 using the wiring information shown in table 1 and figure 2.

Table 2 Reference Designation Index - NAA11 Power Amplifier

REF DES	NAME OF PART AND DESCRIPTION	NAUTEL'S PART NO.	JAN, MIL OR MFR PART NO.	(OEM) MFR CODE
-	Power Amplifier Module (250 Watts)	NAA11	139-1000	37338
C1	Capacitor, Ceramic, 0.1uF 10%, 100V	CCG07	CKR06BX104KL	56289
C2	Capacitor, Ceramic, 0.1uF 10%, 100V	CCG07	CKR06BX104KL	56289
C3	Capacitor, Ceramic, 0.1uF 10%, 100V	CCG07	CKR06BX104KL	56289
C4	Capacitor, Ceramic, 0.1uF 10%, 100V	CCG07	CKR06BX104KL	56289
CR1	Diode, Zener, 75 Volts, 1 Watt, 5%	QL30	1N3041B	04713
CR2	Diode	QL10	50 SQ 100	81483
CR3	Diode	QL10	50 SQ 100	81483
CR4	Diode	QL10	50 SQ 100	81483
CR5	Diode	QL10	50 SQ 100	81483
CR6	Diode	QL10	50 SQ 100	81483
CR7	Diode	QL10	50 SQ 100	81483
CR8	Diode	QL10	50 SQ 100	81483
CR9	Diode	QL10	50 SQ 100	81483
P1	Connector, Plug, 8-pin	J004	P3G-5409-LAB	13150
Q1	Transistor, Field Effect, N Channel	QA04	IRF130	81483
Q2	Transistor, Field Effect, N Channel	QA04	IRF130	81483
Q3	Transistor, Field Effect, N Channel	QA04	IRF130	81483
Q4	Transistor, Field Effect, N Channel	QA04	IRF130	81483
Q5	Transistor, Field Effect, N Channel	QA04	IRF130	81483
Q6	Transistor, Field Effect, N Channel	QA04	IRF130	81483
Q7	Transistor, Field Effect, N Channel	QA04	IRF130	81483
Q8	Transistor, Field Effect, N Channel	QA04	IRF130	81483
T1	Transformer, rf	139-1015	139-1015	37338
T2	Transformer, rf	139-1016	139-1016	37338
T3	Transformer, rf	139-1017	139-1017	37338
TP1	Test Point, Teflon	HAJ07	1128-30	18310

Table 2 Quantities Per Unit Index - NAA11 Power Amplifier

NAUTEL'S PART NO.	NAME OF PART AND DESCRIPTION	JAN, MIL OR MFR PART NO.	(OEM) MFR CODE	TOTAL IDENT PARTS
NAA11	Power Amplifier Module (250 Watts)	139-1000	37338	REF
139-1015	Transformer, rf	139-1015	37338	1
139-1016	Transformer, rf	139-1016	37338	1
139-1017	Transformer, rf	139-1017	37338	1
CCG07	Capacitor, Ceramic, 0.1uF 10%, 100V	CKR06BX104KL	56289	4
HAJ07	Test Point, Teflon	1128-30	18310	1
J004	Connector, Plug, 8-pin	P3G-5409-LAB	13150	1
QA04	Transistor, Field Effect, N Channel	IRF130	81483	8
QL10	Diode	50 SQ 100	81483	8
QL30	Diode, Zener, 75 Volts, 1 Watt, 5%	1N3041B	04713	1

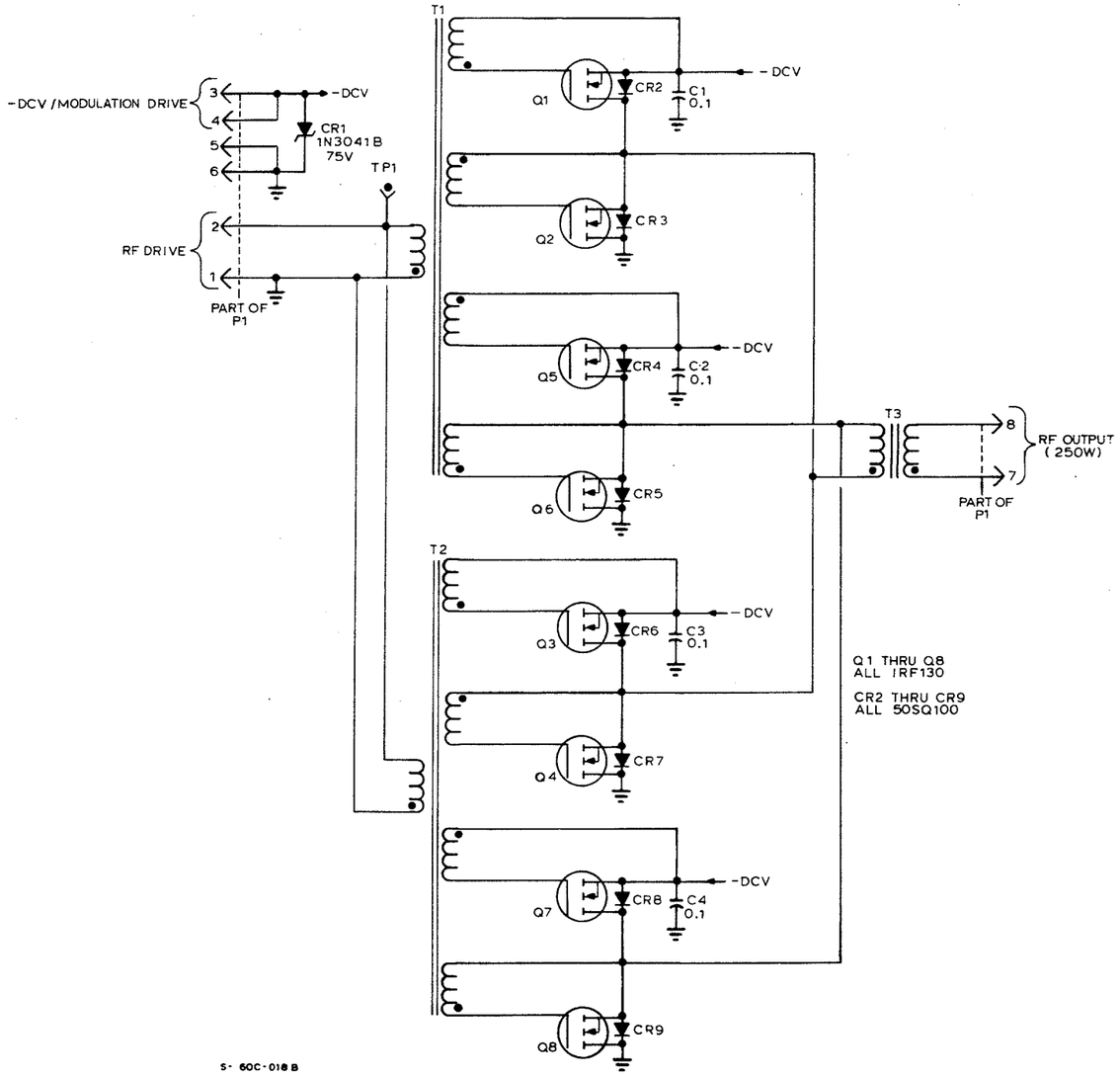
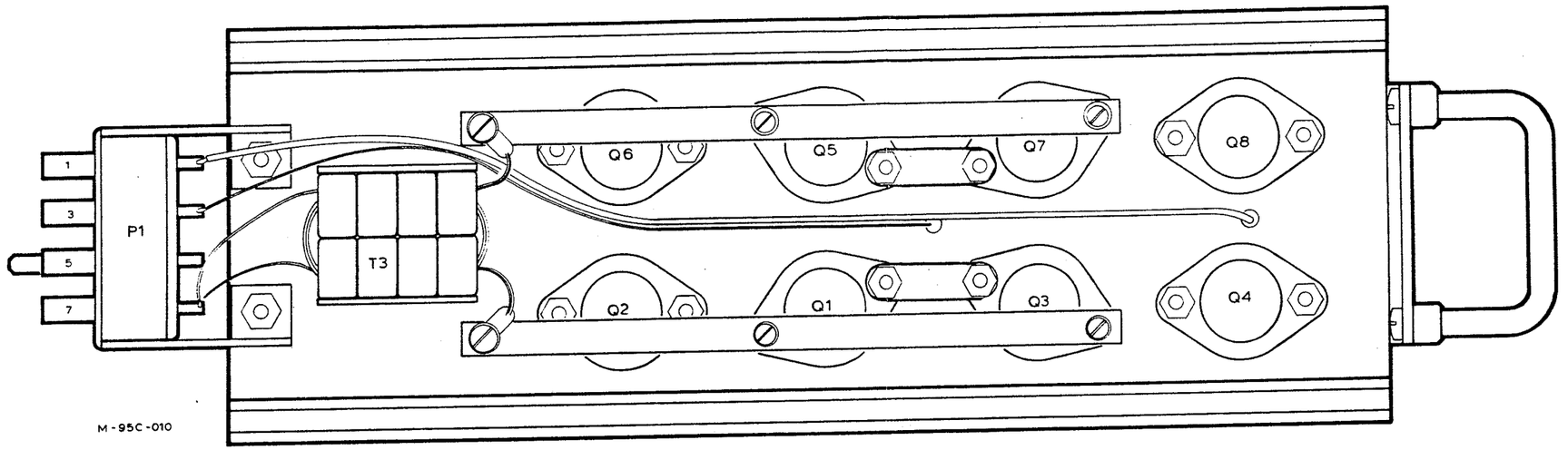


Figure 1 Electrical Schematic - NAA11 Power Amplifier



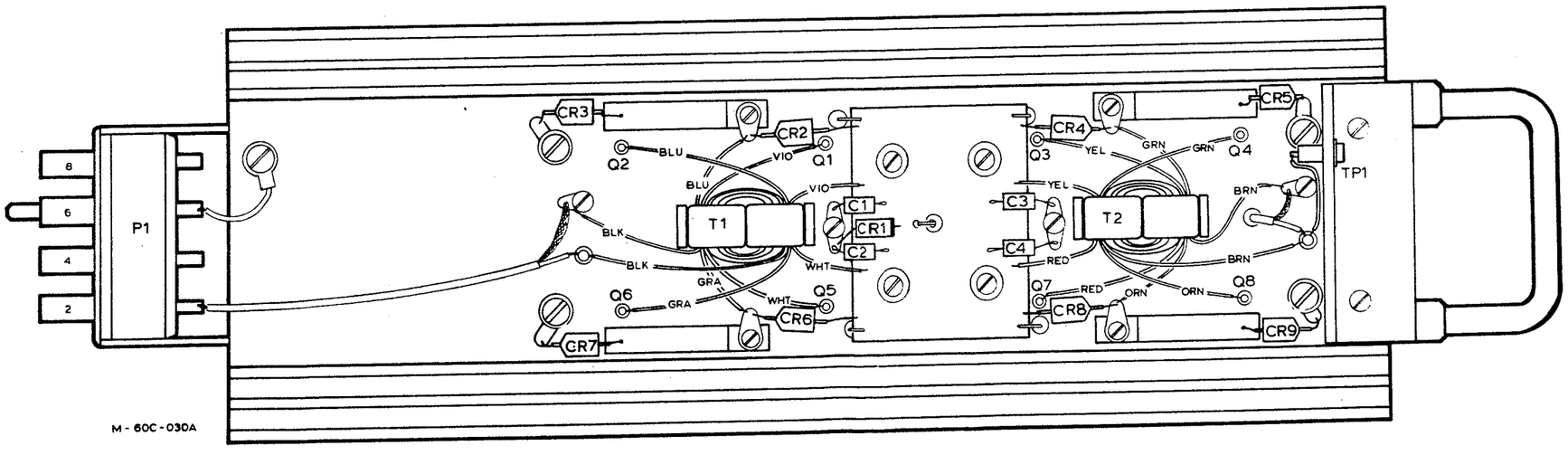
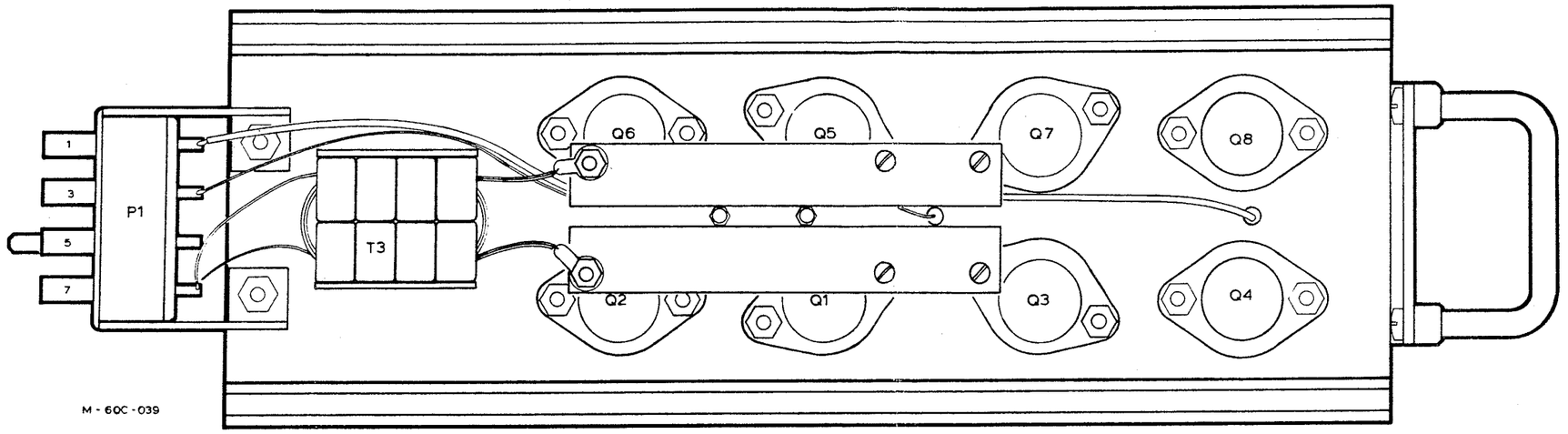
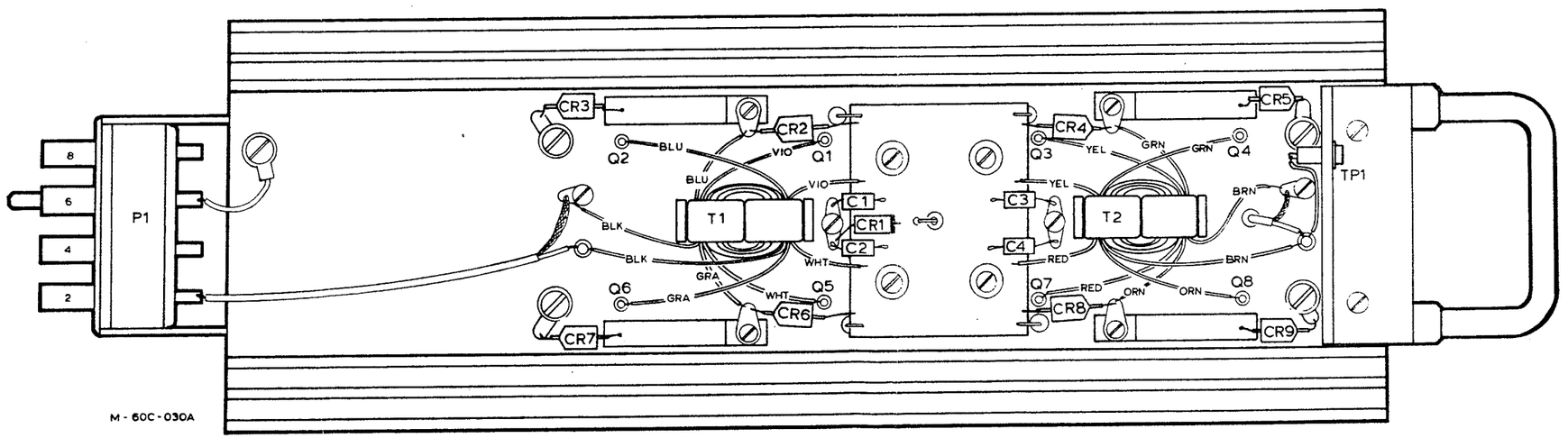


Figure 2A Assembly Detail - NAA11 Power Amplifier (Variation 1)





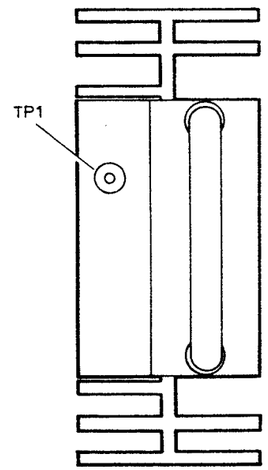
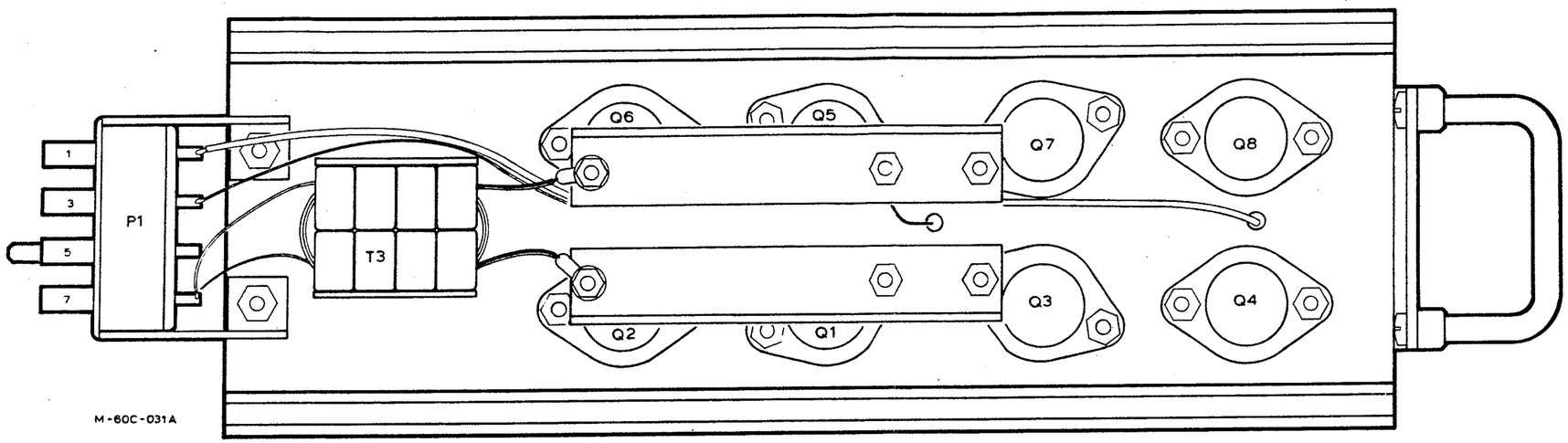
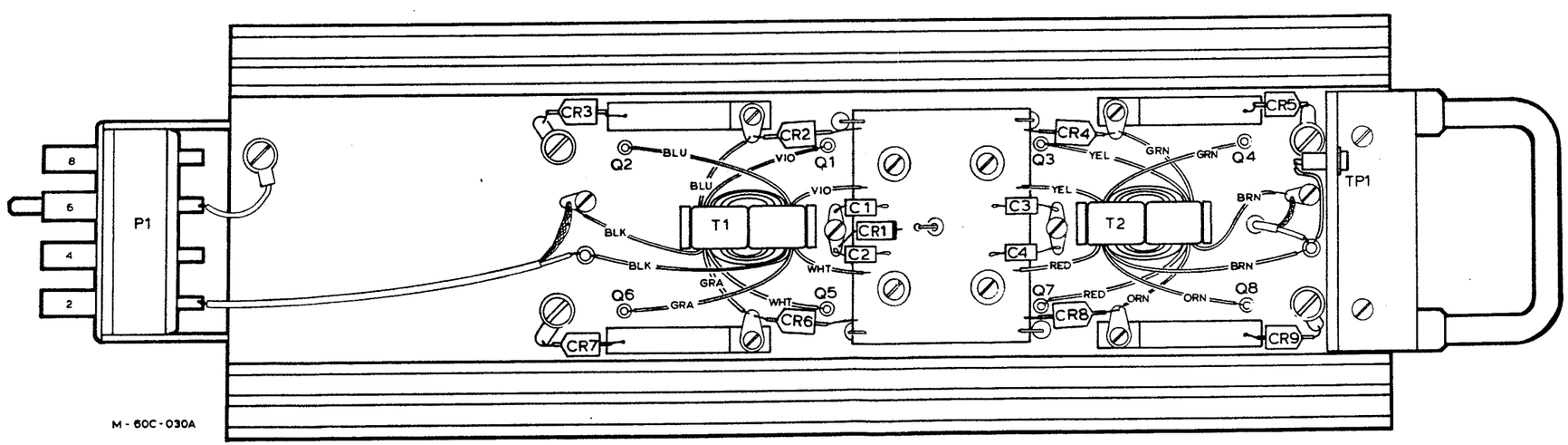


Figure 2B NAA11 Power Amplifier (Variation 2)





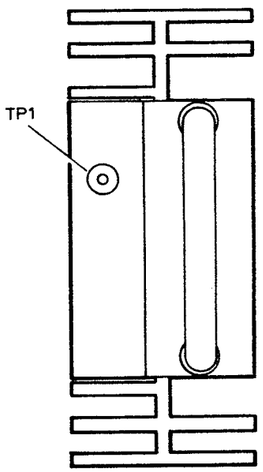


Figure 2C NAA11 Power Amplifier (Variation 3)