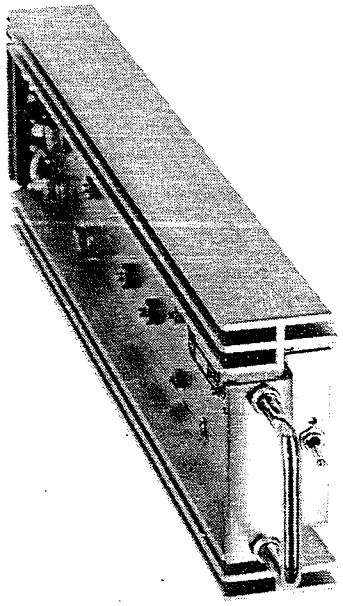
SERVICE INSTRUCTION

NAS15A

RECTIFIER/REGULATOR MODULE



NAUTICAL ELECTRONIC LABORATORIES LIMITED

RR1 TANTALLON, HACKETT'S COVE

HALIFAX COUNTY, NOVA SCOTIA, CANADA

B0J 3J0

RECTIFIER/REGULATOR MODULE
NAS15A

LIST OF EFFECTIVE PAGES

The list of effective pages lists the status of all pages in this manual. Pages of the original issue are identified by a zero in the Change No. column. Pages subsequently changed are identified by the date of the change number. On a changed page, the text affected by the latest change is indicated by a vertical bar in the margin opposite the changed material.

Original . . . . 15 May 1986

Total number of printed sides in this manual is 14 as listed below:

PAGE	CHANGE No.	DATE	PAGE	CHANGE No.	DATE
Title	0	15 May 1986	6	0	15 May 1986
	-	Blank	7	0	15 May 1986
Effective (Page 1)	0	15 May 1986	8	0	15 May 1986
Effective (Page 2)	-	Blank	9	0	15 May 1986
1	0	15 May 1986	10	-	Blank
2	0	15 May 1986	FO-1	0	15 May 1986
3	0	15 May 1986	FO-2	0	15 May 1986
4	0	15 May 1986	FO-2	0	15 May 1986
5	0	15 May 1986			

INTRODUCTION

1. The NAS15A rectifier/regulator module contains the rectifiers and regulator for the -72 volt dc power supply of Nautel AMPFET transmitters that have a single-phase ac power source. Troubleshooting and repair of the module is performed on a work bench, independent of its associated transmitter. This document provides information required for a competent technician to understand the operation of electrical circuits and procedures to restore defective modules to 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 transmitters. Users may utilize this service for a nominal fee.

MECHANICAL CONFIGURATION

3. The NAS15A rectifier/regulator module utilizes an extruded, finned, heat sink as the module chassis. Two thyristor rectifiers, one power diode, four fuses, and a thermal switch are mounted directly on the heat sink to ensure optimum heat dissipation during operation. The remaining electrical components are mounted on a printed circuit board. The electrical connector is installed on the rear of the heat sink. A panel containing a handle and the on/off switch is installed on the front. Interconnection of components mounted on the heat sink is by soldering directly to terminals or terminal lugs on the components. Interconnections to the printed circuit board is by soldering to standoff terminals on the circuit board. Components on the printed circuit board are interconnected by the circuit board's printed wiring pattern. Refer to figure FO-2 for assembly detail of the rectifier/regulator module.

THEORY OF OPERATION

4. The NAS15A rectifier/regulator module full-wave rectifies the 81-0-81 volts ac from the associated transmitter's power supply and provides regulated, -72 volts dc to the transmitter's rf power stage. Refer to figure FO-1 for the electrical schematic.

4.1 INITIAL TURN-ON: At initial turn-on, thyristors Q1 and Q2 will not be conducting. Current will not be flowing thru the associated transmitter's power transformer/filter choke; therefore, there will not be a negative voltage on P1-5. When switch S2 is closed (on), 24 volts dc is applied thru S2 and thermostat S1, to voltage divider A1R9/A1CR2/A1R12. The voltage at the junction of A1R9/A1CR2 (12 vdc) will be applied to the base of transistor A1Q2 thru A1R6/A1R7. A1Q2 will be forward biased (turned on) and cause transistor A1Q1 to be forward biased (turned on). When A1Q1 is turned on, the gates of thyristors Q1 and Q2 will be forward biased and they will conduct during the positive half cycles of the 81-0-81 volt ac input to their anodes. Current will flow thru the associated transmitter's current shunt resistor, thru Q1 or Q2, thru the 81-0-81 volt ac secondary windings of the transmitter's power transformer, thru the filter choke, to the load; which is the transmitter's rf power stage. A large storage capacitor in the modulator module of the transmitter's rf power stage will start to charge towards -72 volts dc. This negative voltage is applied to P1-5. Resistors A1R8/A1R7/A1R6/A1R9 form a voltage divider between the negative voltage on P1-5 and the 24 volts dc on P1-7. As the negative voltage on P1-5 approaches -72 volts dc, the dc voltage at the junction of A1R7/A1R8 will go less positive until A1Q2 is no longer forward biased. A1Q2 and, therefore, A1Q1 will turn off and thyristors Q1 and Q2 will not conduct. Potentiometer A1R6 is adjusted to provided the precise voltage at the junction of A1R7/A1R8 that will maintain the negative voltage at -72 volts dc. This status will be maintained until the -72 dc voltage decays to a level which will cause the voltage at the junction of A1R7/A1R8 to forward bias A1Q2.

4.2 -72 VOLT DC REGULATION: A full-wave ac ripple is present on the -72 dc voltage. When the storage capacitor in the modulator module of the associate transmitter has charged to -72 volts dc, the dc component of the voltage at the junction of A1R7/A1R8 will be maintained at a level which will just reverse bias transistor A1Q2. The ac ripple component will cause the voltage at the junction of A1R7/A1R8 to forward bias A1Q2 and turn on at some portion of its positive-going excursion. The turn-on point is determined by the current demands from the rf power stage of the associated transmitter and will vary from the start of each half cycle of the ripple during high current demands to a small portion of each half cycle during low current demands. See figure 1 for typical timing and waveform relationships. Rectifier A1CR3/A1CR4, which full-wave rectifies the 17.5-0-17.5 volt ac input from the associated transmitter's power transformer, provides an ac voltage at the junction of A1R11/A1R12. This ac voltage, which is in phase with, and supplements the ac ripple on the -72 volts dc, ensures thyristors Q1 and Q2 will conduct during some portion of each half cycle of the 81-0-81 ac voltage on their anodes.

4.3 THERMAL PROTECTION: Thermostat S1 provides protection against overheating of the rectifier/regulator module. It will go to its open circuit position when the sensed temperature exceeds 85°C, and switch off the rectifier/regulator module.

4.4 SHUTDOWN/ABRUPT LOAD CHANGE PROTECTION: When the rectifier/regulator is turned off, or when the current demands of the rf power stage of the associated transmitter are abruptly changed, free wheeling diode CR1 protects the thyristors from an overvoltage condition by providing a path to ground for voltages induced in the filter choke of the associated transmitter's power supply by the collapsing current.

FUNCTIONAL TEST

5. Functional testing of an NAS15A rectifier/regulator on a work bench requires specialized test equipment not normally available outside the factory. The only practical method of functionally testing a rectifier/regulator module in the field is to install it in an AMPFET transmitter and verify it is providing -72 volts to the rf power stage of the associated transmitter.

CAUTION

Observe the operating precautions noted in section 4 of the AMPFET transmitter's instruction manual when removing the NAS15A rectifier/regulator from a transmitter. Damage to mating connectors, or destruction of solid state devices, may result if a rectifier/regulator is removed when it or the transmitter is turned on.

NOTE

Final testing and adjustment of the rectifier/regulator module is performed with the module installed in the transmitter. Instructions are provided in the associated transmitter's instruction manual.

TROUBLE SHOOTING

6. Troubleshooting of the NAS15A rectifier/regulator module consists of a visual inspection and resistance measurements. Isolate a defective component or a fault in the module as follows.

6.1 TEST EQUIPMENT AND SPECIAL TOOLS: The following test equipment and special tools are required:

6.1.2 Test Equipment: Test equipment required to troubleshoot the rectifier/regulator module includes:

(a) A digital multimeter that can accurately measure resistances, including reverse/forward diode resistances.

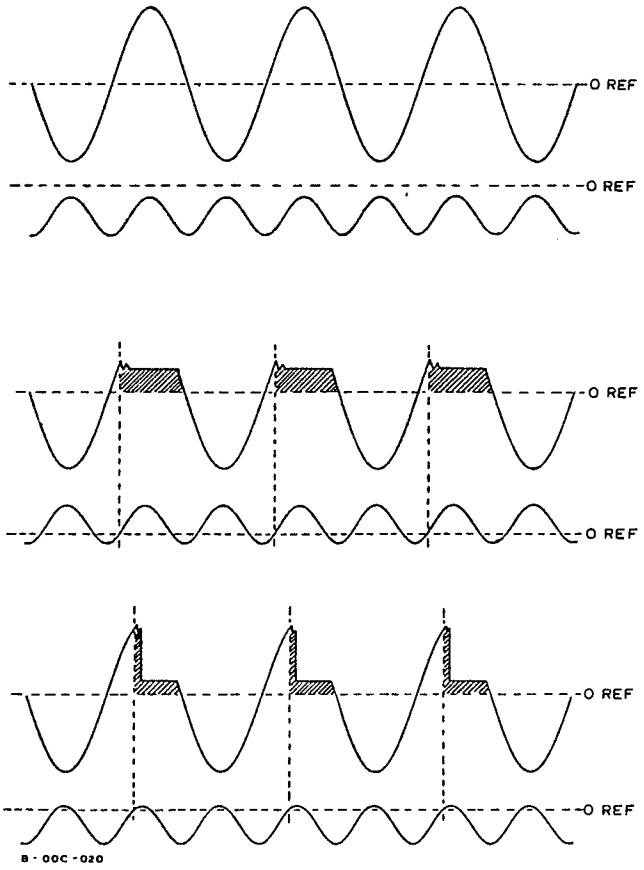
(b) A 15 volt dc power supply rated at one ampere minimum, with an integral current meter.

6.1.2 Special Tools: Special tools required to repair the rectifier/regulator module include:

(a) Two 7/16 inch, open end wrenches.

(b) One 1/2 inch, open end wrench.

(c) One 5/8 inch, open end wrench.



VOLTAGE ON THYRISTOR ANODE

VOLTAGE ON THYRISTOR GATE

MAXIMUM
TURN ON TIME

MINIMUM
TURN ON TIME

Figure 1 Typical Thyristor Timing/Phasing Waveforms

6.2 VISUAL INSPECTION: Perform the following visual inspections.

(a) Inspect all electrical components for evidence of overheating or physical damage.

(b) Verify fuses F1, F2, F3 and F4 are not defective and F3 and F4 are the correct value.

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

(d) Verify connector P1 does not contain damaged or loose pins and that it is securely fastened to the heat sink.

(e) Verify all wiring insulation is not pinched, frayed, broken or otherwise damaged.

(f) Verify wire strands of wiring conductors are not broken or otherwise damaged.

(g) Verify heat sink and printed circuit board are free from solder slivers and other conductive foreign objects.

(h) Verify all fastening hardware is securely tightened, paying particular attention to retaining nuts of fuses F1 and F2, thyristors Q1 and Q2, and diode CR1.

6.3 RESISTANCE MEASUREMENTS: Isolate defective components by performing a resistance measurement of each device and an electrical test on the thyristors as follows:

NOTE
Components can be checked while still mechanically mounted. Provision must be made for parallel resistances when measuring some components in the regulator circuit.

(a) Verify resistance between thyristor Q1's anode and ground, and between thyristor Q2's anode and ground is greater than 2 megohms.

(b) Connect a current limited, dc power supply, set to 15 volts dc, between anode (positive) and cathode (negative) of thyristor to be tested (Q1 or Q2), in turn, ensuring test leads do not touch the chassis.

(i) Dc power supply's current meter should indicate zero amperes.

(ii) Momentarily connect a 1000 ohm resistor between thyristor's anode and gate.

(iii) Thyristor shall turn on and stay on as indicated by power supply's current meter.

(iv) Turn off and disconnect the 15 volt dc power supply.

(c) Verify diode CR1 has a typical forward/reverse diode resistance.

(d) Verify transistor A1Q1 has a typical forward/reverse diode resistance beween its base and emitter, when measured between the end of A1R5 nearest A1R3 and terminal 4 of printed circuit board A1.

(e) Verify transistor A1Q1 has a typical forward/reverse diode resistance beween its base and collector, when measured between the end of A1R5 nearest A1R3 and the junction of A1R1/A1R3.

(f) Verify resistance between transistor A1Q1's emitter and collector is not a short circuit in both directions.

NOTE

A1Q1 will appear to have a typical forward/reverse diode resistance between its emitter and collector when it is in circuit and the regulator circuit is intact.

(g) Verify transistor A1Q2 has a typical forward/reverse diode resistance beween its base and emitter, when measured between the junction of A1R7/A1R8 and ground.

(h) Verify transistor A1Q2 has a typical forward/reverse diode resistance beween its base and collector, when measured between the junction of A1R7/A1R8 and the end of A1R5 nearest A1R7.

(i) Verify resistance between transistor A1Q2's emitter and collector is an open circuit in both directions, when measured between ground and the end of A1R5 nearest A1R7.

REPAIR

7. There are no special repair instructions for components mounted on the printed circuit board. Observe normal care and precautions when removing and replacing components soldered to the printed wiring pattern. The following must be observed when replacing components mounted on the heat sink.

NOTE

Refer to table 1 for interconnecting wiring information and to figure FO-2 for assembly detail of the rectifier/regulator module.

7.1 REPLACEMENT OF THYRISTORS: Replace thyristors Q1 and Q2 as follows:

(a) Unsolder the leads from the anode, gate and cathode.

(b) Prevent body of thyristor from turning by holding it with a 1/2 inch wrench and then remove its retaining nut using a 7/16 inch wrench.

(c) Remove defective thyristor.

(d) Install replacement thyristor using hardware from defective thyristor.

(e) Prevent body of thyristor from turning by holding it with a 1/2 inch wrench and then tighten its retaining nut to a torque of 25 to 30 inch/pounds, using a 7/16 inch wrench.

(f) Solder leads removed in step (a) to thyristor's anode, gate and cathode connections.

7.2 REPLACEMENT OF DIODE CR1: There are no special instructions for installing diode CR1, other than the tightening of its retaining nut. Prevent body of diode from turning by holding it with a 5/8 inch wrench and then tighten its retaining nut to a torque of 20 to 25 inch/pounds, using a 7/16 inch wrench.

7.3 REPACEMENT OF FUSES F1 AND F2: Replace fuses F1 and F2 as follows:

(a) Remove insulators from the fuse retaining nuts, by prying them off with a screw driver. Retain insulators for reuse.

(b) Prevent fuse mounting bolts from turning by holding them on the reverse side of the heat sink with a 7/16 inch wrench; then remove retaining nuts using a 7/16 inch wrench.

(c) Remove defective fuse.

(d) Verify insulating spacer in the fuse mounting bolt hole is not damaged and mounting bolt retaining nut is torqued from 20 to 25 inch/pounds. Ensure terminal lugs on interconnecting leads are not shorting to the heat sink.

(e) Install replacement fuse.

(f) Prevent fuse mounting bolts from turning by holding them on the reverse side of the heat sink with a 7/16 inch wrench; then tighten retaining nuts to a torque of 40 to 50 inch/pounds, using a 7/16 inch wrench.

(g) Install insulators removed in step (a) on the fuse retaining nuts.

Table 1 Wiring List - NAS15A Rectifier/Regulator Module

SOURCE	DESTINATION	CODE		SIZE	FUNCTION
P1-2	F2-1	1	White/Grey	16	
P1-4	F2-1	2	White/Grey	16	
P1-13	F2-1	3	White/Grey	16	
P1-6/14	Pin A	4	Black	14	
P1-8/16	Pin A	5	Black	14	
-	-	6	Not Used		
-	-	7	Not Used		
P1-10	F1-1	8	White/Grey	16	
P1-12	F1-1	9	White/Grey	16	
P1-15	F1-1	10	White/Grey	16	
P1-1	CR1-A	11	White/Grey	14	
P1-3	Pin B Gnd	12	Black	14	
Q1-Cathode	Pin A	13	Black	14	
Q2-Cathode	Pin A	14	Black	14	
F1-2	Q1-Anode	15	White/Grey	14	
F2-2	Q2-Anode	16	White/Grey	14	
P1-5	A1-3	17	Blue	22	
P1-7	S2-2	18	Orange	22	
S2-3	S1-1	19	Orange	22	
S1-2	A1-4	20	Orange	22	
P1-9	F3-1	21	White/Grey	22	
P1-11	F4-1	22	White/Grey	22	
F3-2	A1-5	23	White/Grey	22	
F4-2	A1-6	24	White/Grey	22	
Q1-Gate	A1-1	25	White	22	
Q2-Gate	A1-2	26	White	22	

Table 2 NAS15A Reference Designation Index

REF DES	NAME OF PART AND DESCRIPTION	NAUTEL's PART NO.	JAN, MIL OR MFR PART NO.
-	Rectifier/Regulator Module	NAS15A	139-5040-1
A1	Rectifier/Regulator PCB Assembly	139-5045	139-5045
A1C1	Capacitor, Tantalum, 1.0uF 10%, 50V	CCP24	CSR13G105KM
A1C2	Capacitor, Tantalum, 1.0uF 10%, 50V	CCP24	CSR13G105KM
A1C3	Capacitor, Tantalum, 22uF 10%, 35V	CCP20	CSR13F226KM
A1CR1	Diode, General Purpose, Small Signal	QAP29	1N4938
A1CR2	Diode, Zener, 12.0V, 400mW, 10%	QG08	1N759
A1CR3	Diode, Power Rectifier, 3A	QG31	1N5624
A1CR4	Diode, Power Rectifier, 3A	QG31	1N5624
A1Q1	Transistor, PNP	QAP09	2N2907
A1Q2	Transistor, NPN, High Gain, Low Noise	QA35	2N930
A1R 1	Resistor, Comp, 560 ohms, 5% 2W	RI34	RC42GF561J
A1R 2	Resistor, Film, 1000 ohms, 2% 1/2W	RAP09	RL20S102G
A1R 3	Resistor, Comp, 560 ohms, 5% 2W	RI34	RC42GF561J
A1R 4	Resistor, Film, 1000 ohms, 2% 1/2W	RAP09	RL20S102G
A1R 5	Resistor, Eilm, 10K ohms, 2% 1/2W	RAP13	RL20S103G
A1R 6	Resistor, Variable, 10K ohms, 1/2W	RW04	3339-W-1-103
A1R 7	Resistor, Film, 39K ohms, 2% 1/2W	RD14	RL20S393G
A1R 8	Resistor, Film, 270K ohms, 2% 1/2W	RD24	RL20S274G
A1R 9	Resistor, Film, 18K ohms, 2% 1/2W	RAP14	RL20S183G
A1R10	Resistor, Film, 1800 ohms, 2% 1/2W	RAP10	RL20S182G
A1R11	Resistor, Film, 1000 ohms, 2% 1/2W	RAP09	RL20S102G
A1R12	Resistor, Film, 18 ohms, 2% 1/2W	RAP02	RL20S180G
CR1	Diode, Power Rectifier, 40A	QK17	1N1187A
F1	Fuse, 40A, 130V	FC04	ANN40
F2	Fuse, 40A, 130V	FC04	ANN40
F3	Fuse, 0.25A, 250V, Slo-Blo, Type 3AB	FB11	323.250
F4	Fuse, 0.25A, 250V, Slo-Blo, Type 3AB	FB11	323.250
P1	Connector, Plug, 16-pin, 250V	JO10	P3-5416-SB
Q1	Thyristor, Power, Insulated Stud	QB31	MCR65-6
Q2	Thyristor, Power, Insulated Stud	QB31	MCR65-6
S1	Switch, Thermal, 1PST-NC, 85°C	SC17	3455RM-87
S2	Switch, Toggle, 1PDT	SA26	MST-105D
XF1	Not Used		
XF2	Not Used		
XF3	Fuse Block, 2 Pole, Type 3AG	FA25	357002

Table 3 NAS15A Quantities Per Unit Index

NAUTEL'S PART NO.	NAME OF PART AND DESCRIPTION	JAN, MIL OR MFR PART NO.	OEM CODE	TOTAL IDENT PARTS
NAS15A	Rectifier/Regulator Module	139-5040-1	37338	-
139-5045	Rectifier/Regulator PCB Assembly	139-5045	37338	1
CCP20	Capacitor, Tantalum, 22uF 10%, 35V	CSR13F226KM	56289	1
CCP24	Capacitor, Tantalum, 1.0uF 10%, 50V	CSR13G105KM	56289	2
FA25	Fuse Block, 2 Pole, Type 3AG	357002	75915	1
FB11	Fuse, 0.25A, 250V, Slo-Blo, Type 3AB	323.250	75915	2
FC04	Fuse, 40A, 130V	ANN40	71400	2
JO10	Connector, Plug, 16-pin, 250V	P3-5416-SB	13150	1
QA35	Transistor, NPN, High Gain, Low Noise	2N930	04713	1
QAP09	Transistor, PNP	2N2907	04713	1
QAP29	Diode, General Purpose, Small Signal	1N4938	01295	1
QB31	Thyristor, Power, Insulated Stud	MCR65-6	04713	2
QG08	Diode, Zener, 12.0V, 400mW, 10%	1N759	04713	1
QG31	Diode, Power Rectifier, 3A	1N5624	89473	2
QK17	Diode, Power Rectifier, 40A	1N1187A	04713	1
RAP02	Resistor, Film, 18 ohms, 2% 1/2W	RL20S180G	36002	1
RAP09	Resistor, Film, 1000 ohms, 2% 1/2W	RL20S102G	36002	3
RAP10	Resistor, Film, 1800 ohms, 2% 1/2W	RL20S182G	36002	1
RAP13	Resistor, Film, 10K ohms, 2% 1/2W	RL20S103G	36002	1
RAP14	Resistor, Film, 18K ohms, 2% 1/2W	RL20S183G	36002	1
RD14	Resistor, Film, 39K ohms, 2% 1/2W	RL20S393G	36002	2
RI34	Resistor, Comp, 560 ohms, 5% 2W	RC42GF561J	36002	2
RW04	Resistor, Variable, 10K ohms, 1/2W	3339-W-1-103	80294	1
SA26	Switch, Toggle, 1PDT	MST-105D	95146	1
SC17	Switch, Thermal, 1PST-NC, 85°C	3455RM-87	14604	1

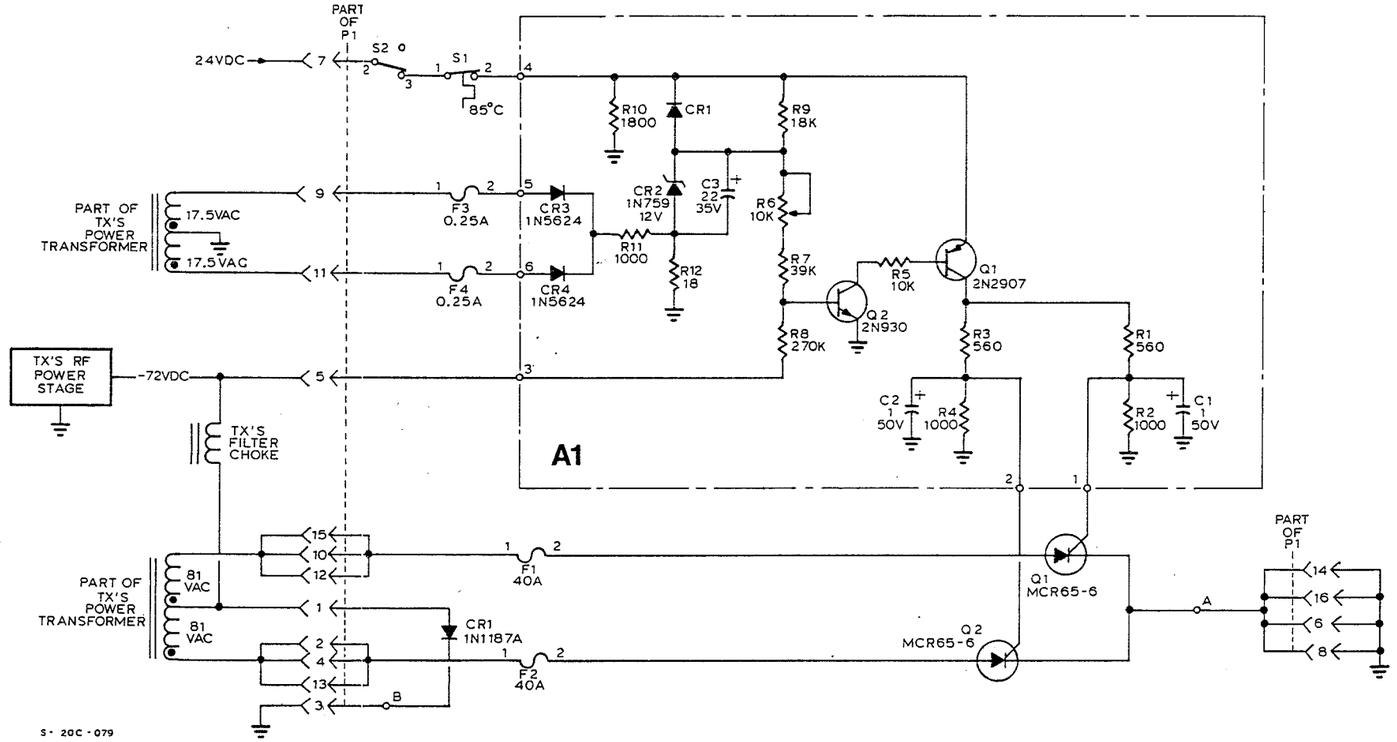
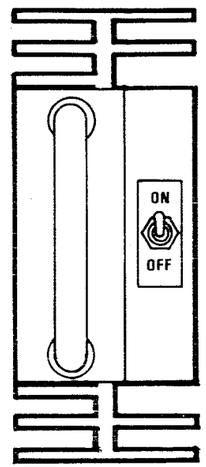
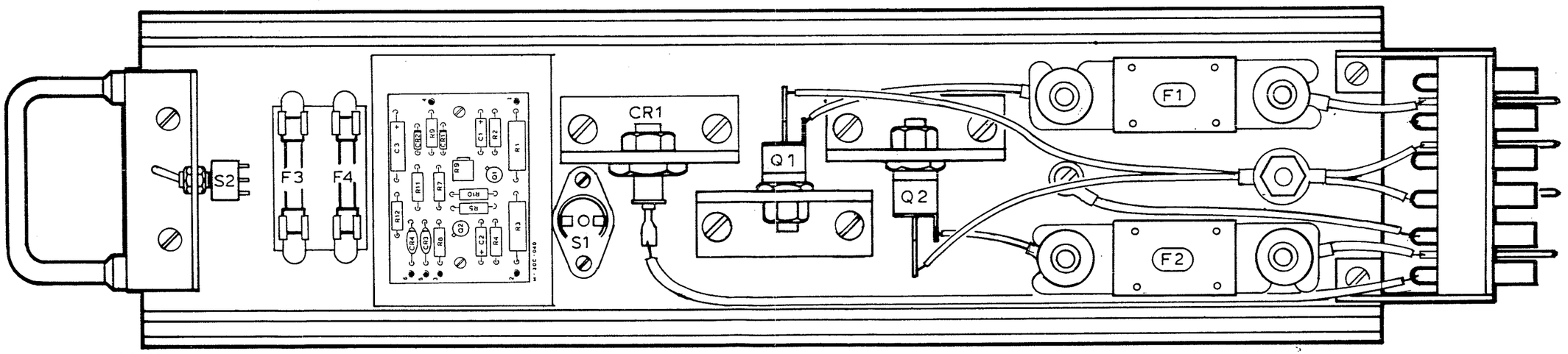


Figure FO-1 Electrical Schematic - NAS15A Rectifier/Regulator Module





M - 20C-122

Figure FO-2 Assembly Detail - NAS15A Rectifier/Regulator Module