History & Characteristics

The AN/GRC-106 was developed in the early 1960's as a replacement for the AN/GRC-19, a heavy auto-tune set comprising of the T-195 transmitter and the R-392 receiver. The "angry" 19 was AM voice and getting old, it was in its third upgrade, and only 100 watts. And, its frequency range was limited to 1.5 to 22 mHz whereas the '106 is 2.0 to 29.999 MHz. The military saw the benefits of SSB and solid state construction and ordered thousands of these sets in the mid 1960's. They missed the mark on completely solid state however as the technology was not yet there so these sets do contain 5 vacuum tubes. Early sets were built using germanium devices, which were the common components of that period. The '106 is limited to USB only, many military sets are, as it simplified the set and there was no chance of the operator being on the wrong side band. The weight is still high at 120 lbs for the basic set, but better then the 260 lbs. of the '19.

My Signal Corp unit began seeing the '106 show up about 1969 in RTTY communications shelters commonly called "ratt rigs". Early models had the RT-662 as the receiver and exciter, tunable in 1 kHz steps, whereas the later RT-834 has 100 Hz steps. The sets using the RT-834 were suffixed and became the AN/GRC-106A. There were several modifications to both RT models over the years but to my knowledge, there were never changes to the RT designations. The amplifier, rated 400 watts PEP, is the AM-3349. Here again, there were modifications, both major and minor, but the designation never changed. Both the RT and the Amplifier underwent a siliconization upgrade in later years but not all early sets received the new modules. For that reason, you may find sets with both germanium and silicone components intermixed.

By the mid to late 1980's the '106 sets were being replaced as smaller more modern sets were developed. Surplus sales, and foreign exports, began during this period and hams who were military radio enthusiasts began using them "as

is" and also modifying them for USB/LSB operation. In the military, during this period, when an RT or amplifier needed service or repair, it was often just replaced and the non-working set sent to a depot for disposition. This is why most of the sets encountered in the surplus market were and still are in some need of repair. Surplus sales in later years included working units and depot overhauls but unfortunately many were de-milled by removing the meters, knobs and sometimes parts were salvaged. Sets also languished for years in depots and, as we will point out later, problems can develop from lack of use. By the 1990's the set was mainly used by Guard and Reserve units and was being phased out completely elsewhere.

Since I had military experience with the '106, both with operation and servicing, I began helping fellow hams repair them back in the 90's. Many were on the market then, with few in working order. Prices and conditions varied, and still do, based mainly on "where is-as is" as shipping is high due to the size and weight.

Maintenance

Over the years I discovered many sets to have similar problems and quickly learned what to look for during trouble shooting. This article will share my experiences and help you get a non-working set on the air. The article is not intended for in depth repairs at the component level or to address every situation. We will cover basic repairs, as specialized test trays, test equipment and/or extender modules are required in many instances. Where a module replacement is recommended, the reader can opt to repair it if desired.

The Manuals, Modules and Components;

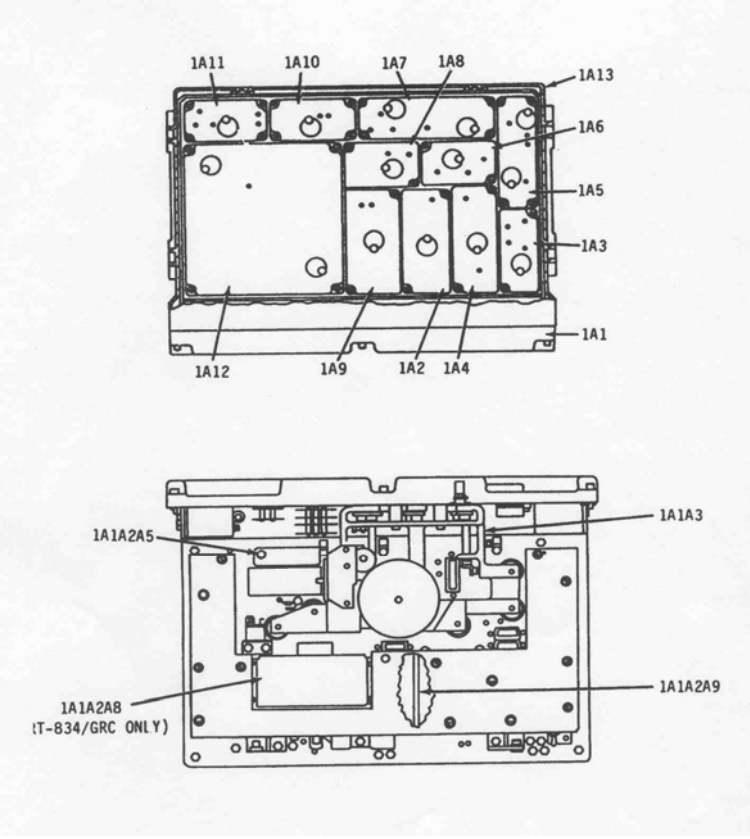
The operator manual is a MUST! Many of the problems the military experienced with the '106 can be directly related to operator error as tuning procedures were not followed. Make sure you get a copy of TM 11-5820-520-10 before attempting operation and tune up. Depot level manuals are certainly a good item to have around and will aid in any repairs. I have several versions on hand and each has a different level of information. The first issue was TM 11-5820-520-35 and is dated 1966. This is a good reference but only for the early sets. It does not include any of the later modifications, or the RT-832, but if you have an early unmodified set it is helpful. The next, and in my opinion the best issue, is TM 11-5820-520-34, dated 1972. This version contains great theory and detailed descriptions, but is hard to find in printed version. If you do find a printed copy or even a PDF copy of the 1972 version, most often the drawings are missing or incomplete. The '34 was reissued in a slightly condensed version in 1990. The 1990 version is useful as it contains the silicon conversion information as well as a list of all modifications to that date. Another excellent source of repair and theory information is the set of AN/GRC-106 lesson booklets from the Signal Center School, Ft. Gordon. These are somewhat rare and I consider myself fortunate to have a few of these. Many of these manuals can be found in PDF format online, usually for free, and sometimes appear on internet vendor and auction sites in printed copy.

In the discussions of repairs, we will refer to the modules and components by name and/or number. All modules have their name printed on the module cover

but not all modules you encounter will have their number there. In the manuals, the modules and their components are referenced by number and we will do the same. A list of modules is in Table 1 for the RT's and Table 2 for the amplifier. Also, module locations are shown in Figure 2 for the RT's and Figure 4 for the amplifier.

RT Module Numbers

1A1 Front Panel
1A2 100kHz Synthesizer
1A3 Frequency Standard
1A4 10 & 1 kHz Synthesizer *
1A5 Transmitter IF & Audio
1A6 Frequency Dividers
1A7 Receive IF
1A8 Translator
1A9 MHz Synthesizer
1A10 Receive Audio
1A11 DC-DC Converter
1A12 RF Amplifier – Turret
1A13 Not really a module, but a reference to chassis components
1A1A2A8 100 Hz Synthesizer (RT-834 Only)
* Same module number but a completely different module in the RT-662 vs. the RT-834



Components are made up of a series of numbers and letters which tell you where they are located. For example 1A7A1Q1 is a transistor, Q1, located on circuit board A1. Circuit board A1 is located in Module 1A7. Sounds simple but in some instances there can be 2 or more boards on a main board, and even sub

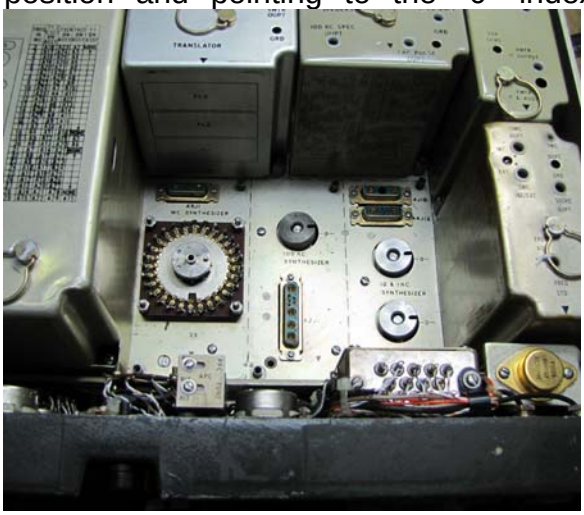
boards on sub boards so the identifiers can get quite long. In the manuals, a component number will usually not include the module prefix as they assume you know what module you are working on.

RT-662 and 834 Frequent Problems

If your RT powers up, meaning you get meter swing when switched to the standby mode, but is otherwise dead, slide the RT out of its case and check the test point voltages on the 1A11 module. If the module is not outputting the proper voltages, repair or replace it before going to the next step.

The #1 problem I have encountered is the 1A3 frequency standard module being defective. Maybe that's why it is also the first item in the troubleshooting charts and is the hardest one to find on the parts market? If you have a frequency counter, check the output at the front panel BNC connector marked "FREQ. STD". It should be 5 MHz +/- 1 or 2 cycles after a 20 minute warm up. If defective, most often you will get a reading of 5.1 or 5.2 MHz or other readings that are way out from 5 MHz, or nothing at all. If you have the manuals and want to get into the module for repairs, this one can be repaired on the bench. You need a good 20 volt regulated supply to power the module and a separate 28 volt supply for the oven but you can repair it without the oven being on. Most often the problem is capacitors inside the oscillator A1 assembly which is inside the oven. If you do get 5 MHz, check the 1 and 10 MHz outputs for correct readings. Those test points are on top of the module

Next on the list are the 1A9, 1A2 and 1A4 modules. Any of these three modules may have similar problems so we will look at all 3 at the same time. These modules could have mechanical as well as electronic problems. So, assuming you are still powered up set your front panel frequency selectors to 15000(0) and wait for the turret to stop. Then shut down and remove power. Take a look at the mHz window on the 1A12 turret cover. It should say 15. If not, you have a gear train problem which will require further investigation and in-depth repairs. If OK, get a Phillips screwdriver and remove all three of the modules mentioned. The pins and slots of the drive couplings should all be at EXACTLY the 3o'clock position and pointing to the "0" index mark. This is shown in figure 3.



If not, get a .050 Allen wrench and adjust them. If OK, turn over the modules and make sure each module's pin or slot is also pointing to its "0" index mark

stamped next to the coupling. Often encountered electronic problems in these modules are bad crystals and the modules' oscillators unlocking. Again, check the frequencies read at the test points against the charts in the manuals. If you have a bad crystal in any of the modules, you will have no operation on some frequencies but it will work on others. Make a list of those frequencies not working and from that, you can determine what crystal(s) are defective and in what module, using the manual charts. Other component repairs are difficult because test trays or extenders are needed to check components and make tests while powered so a replacement module is usually in order. If you need a 1A4 module, make sure it is the right one for your RT. This module kept the same number in both the RT-662 and the RT-834 but they are different. The '662 had two versions with an output of 7.1 mHz and the '834 version is 7.089 mHz out. They have different NSN or part numbers but kept the same module number.

By now you know if the turret is turning when frequencies are entered. If not, the motor may just be frozen from lack of use and stiff lubricant. Check the voltage to the motor, 28 VDC, and if OK tap on the motor case with a screwdriver handle while powered. This will often break it loose.

The service selector switch, on the RT front panel, was a problem on some early models. If the amplifier power switch was left "ON" and the RT is rapidly switched to "SSB" the large inrush current could burn the contacts. Later switches seemed to be OK. Proper start-up procedure is to turn the RT to "Standby", power up the amplifier and wait till the amp's test meter shows voltage in the "PRI VOLT" switch position and then turn the RT to "SSB"

If you have the RT-834, you have the 1A1A2A8 module. This supplies the 100 Hz tuning and can be troublesome. Symptoms include no 100 Hz tuning or being off frequency in both transmit and receive. This module uses propriety IC's that are a form of TTL logic, driving a VCO. The IC's are not available, so a module replacement will be necessary if you experience problems.

We briefly discussed the 1A11 module earlier in this article. This module supplies the regulated voltages for the solid state modules as well as all voltages for the tube circuits. You can check all outputs at the test points. If repairs are needed, this module can be removed and extended using a common DB15 data cable. If you purchase a DB15 M-F cable, make sure it is of good quality, as current draw will exceed the 26 gauge wire found in many cables. It's best to purchase DB15 connectors and make a cable with at least 20 gauge wires. As you will see in the next section about the amplifier, you will need this cable again to do any repairs or tests.

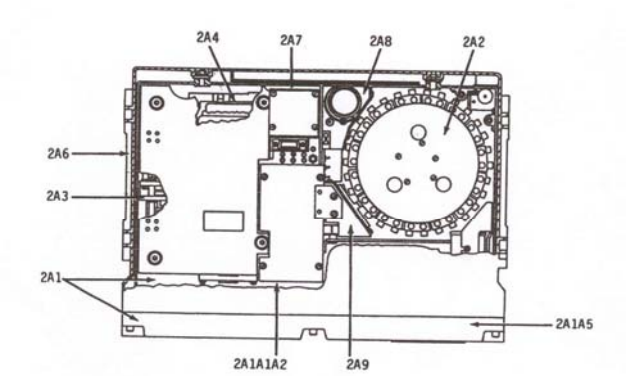
Some less frequent items to fail include the 1A1A1A10 front end protection circuit and the panel meter.

This concludes the more common problems with the RT's. Of course many other things can go wrong and the manuals will guide you through trouble charts. If modules are needed, the usual surplus dealers often have them in stock.

Now we will dive into the AM-3349 and its frequent problems. By far, the amplifier is most often the problem unit in the '106 set. To do any work on the amplifier, you need a very good quality DB15 M-F cable, as mention previously. When the case is removed, the connection is broken to the 2A6 DC-AC power supply module, located in the top of the case. There is also an interlock connection through the same connector to the case so nothing will happen if you try to power up with the case removed. The DB15 cable allows you to set the case aside and use the cable to make the connections back to the chassis. The connection for this is located in the right rear of the chassis and case. You can, if necessary, remove the interconnect socket in the rear of the case and bring it out as the cable can be removed from the straps but it still restricts your separation. Also a 6 foot CX-11016 separation cable is a must. Normally, the amplifier sits on top of the RT and connects with a CX-10099 "dog bone" cable to the RT. Without the separation cable it's difficult to work on the amp as with the case must be removed and there is no slack in the "dog bone". The separation cables show up on the normal bid sites or you can buy a "dog bone", and make your own using the connectors and adding long leads. The amplifier must be connected to the RT, including the RF jumpers, to operate and test. As in the RT section we will reference modules by their number as shown in Table 2.

Amplifier Module Numbers

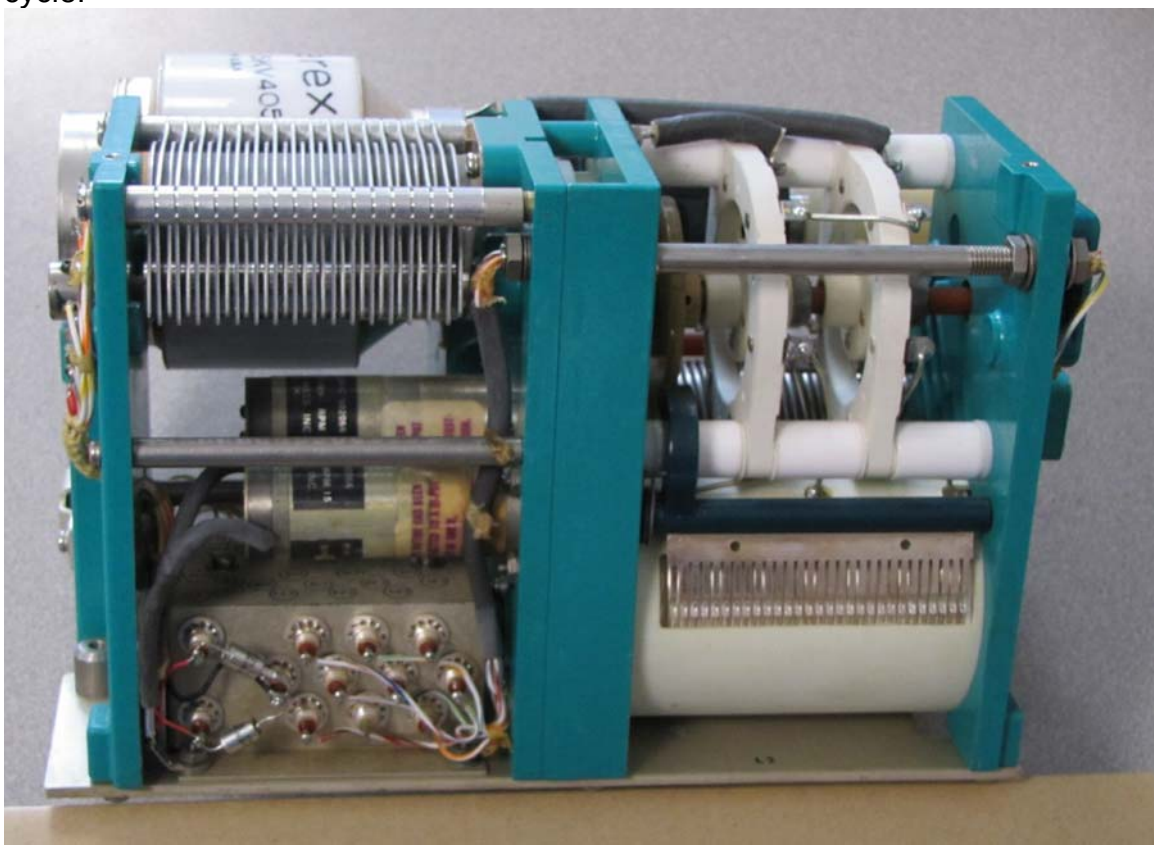
2A1 Chassis Assembly
2A2 Turret Assembly
2A3 Antenna Coupler Assembly
2A4 Discriminator Assembly
2A5 Front Panel Assembly
2A6 Case Assembly
2A7 Relay Assembly
2A8 Driver Assembly
2A9 Stator Assembly



For now, we'll assume your amplifier powers up correctly, your RT is working and you are attempting to tune using the proper procedure. About 3 minutes after turning the amplifier ON, the test meter should show deflection when the test switch is in the PRIM VOLT position. If not, there are many things that can prevent this and those problems are beyond the scope of this article. As in the RT article, we will only address the frequent problems.

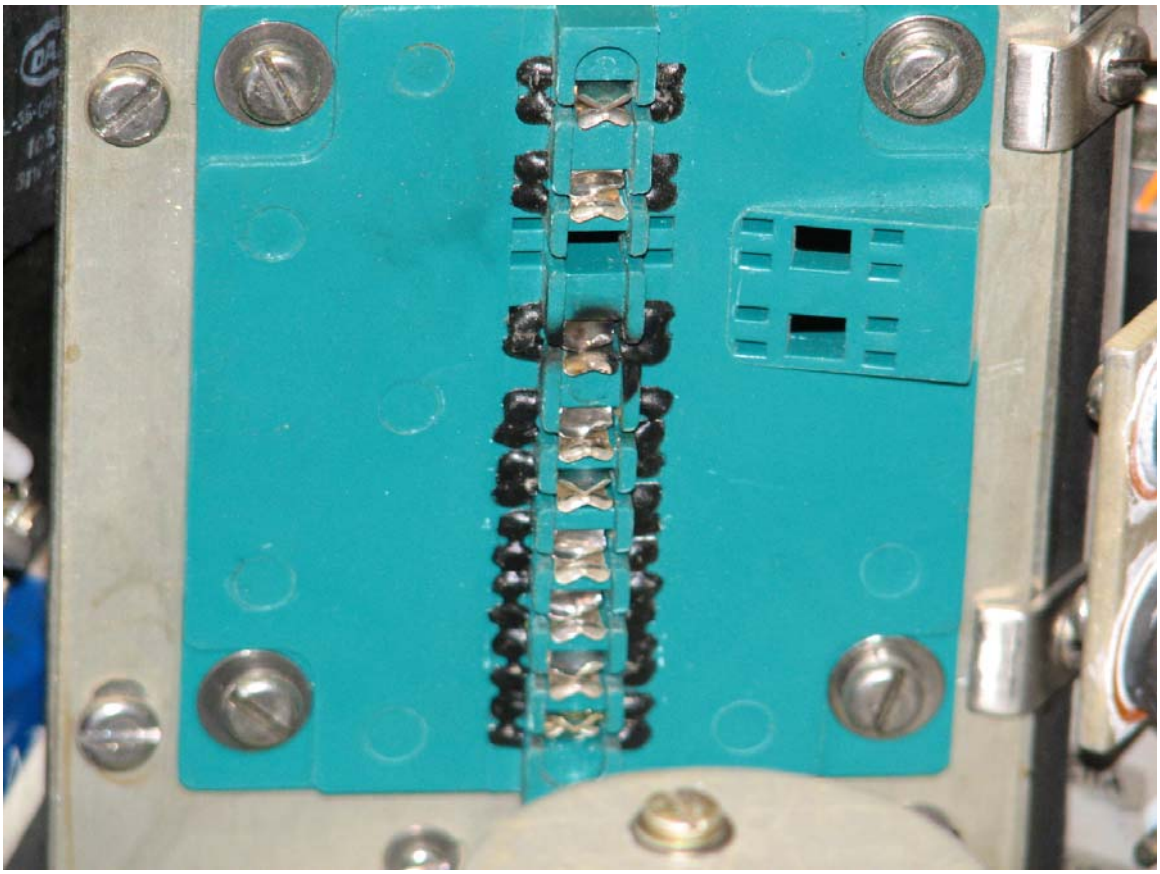
Frequent Amplifier Problems

Can't tune on some frequencies but it does work well on others? It's most likely one or both of the tune motors on the 2A3 Antenna Coupler. These motors will freeze up after a long storage however its usually an easy fix. While the case is removed and the cover over the 2A3 is set aside, (note the high voltage warnings!), attempt to tune on several frequencies separated by quite a few mHz. You should see the turret turn and stop, followed by one or both coupler motors running. One motor drives a variable capacitor and the other drives the band switch. Both will not always activate, depending on the frequency selected so try several frequency settings. If no movements follow the instructions in the manual and remove the 2A3, it's pretty easy. Then follow the wires from the motors to the terminal strip and apply 24 volts DC to each motor separately. If it does not turn, tap it gently at first, with a screwdriver handle. Don't be afraid to increase the tapping and harder if necessary. Once it begins to turn, let it run for a few minutes to free it up. Reinstall the 2A3 and all should be well on the next tune cycle.



Have arcing and smoking from the turret? If so, the 2A2 turret blades and the matching 2A9 stator contacts are most likely burnt or

bent.



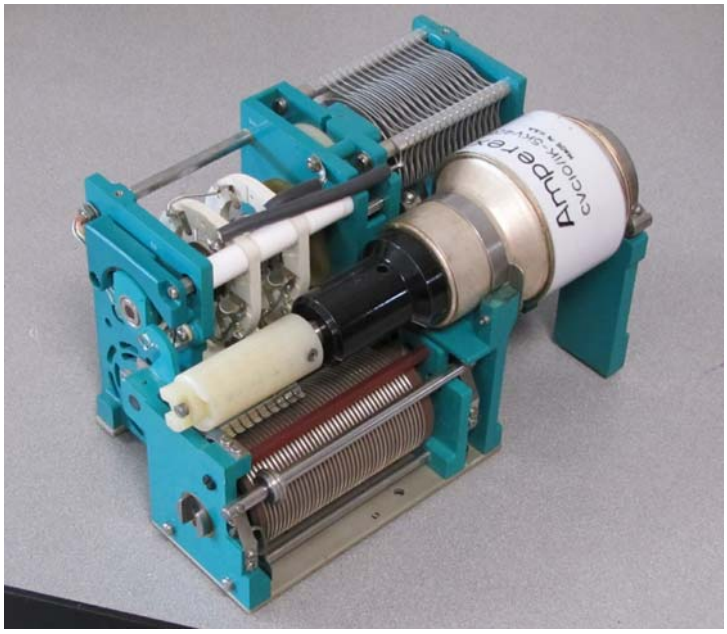
The amplifier was designed so it would not apply high voltage until the turret and the coupler was finished turning. However, often the timing is off and voltage is applied before the contact is made. This results in the contacts being slowly burnt or sometimes welded and then bent. The contracts are then destroyed and replacement is necessary. The 2A9 is the more fragile of the two and will usually need replacement while the 2A2 can be cleaned up. If the 2A2 needs repair, the 2A8 driver contacts, which connect to the 2A2 also, may have suffered as well so check those and repair or replace as necessary. If repairs are necessary, the 2A2 turret must be removed. Care must be taken in the 2A2 removal and I recommend you put a mark on the turret showing its position before removal. That way you can put it back in the same orientation. If you replace the turret with a new one, there are some differences between manufacturers so contact alignment may be necessary.

There are two cooling blowers in the amplifier. The first pushes air into the 2A1A1 plenum assembly and the second is located in the case and exchanges heat from the chassis. These motors also freeze up from lack of use. Power up and listen for the blowers to spool up. If not, give the fans a spin with any available tool and they should run. In early models, the motor in the case is not replaceable and hard to get at to break it free. Rapping on the case above the motor will sometimes break it loose. Later models have an access panel on the top left of the case and the motor can be replaced. The case blower motor is a two speed unit that goes into high speed if the temperature goes up. The thermostat that controls the speeds is located in the heat exchanger near the

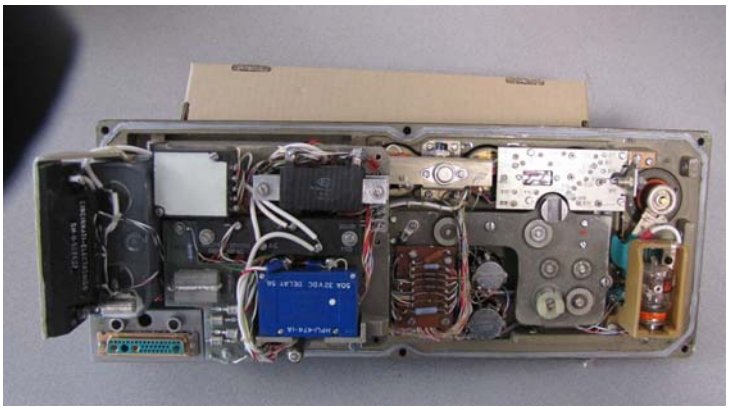
motor. If they still do not operate, you could have a defective 2A6 DC-AC module or, since these are split phase AC motors, the capacitor associated with the motor may be defective. This module provides AC voltage for the blowers, filament voltage for the 2A8 driver and DC bias for the finals. The 2A6 module is repairable as it is easily removed and can be powered using your DB15 M-F cable.

While we are discussing the blowers, an air flow modification was made to later sets and retrofitted to some earlier ones. On the bottom of the amplifier case, you may see a tiny hole in the center of a hex head protrusion. This hole lines up with a tiny pressure switch, located in the bottom of the 2A1A1 plenum, when the amplifier is in the case. If this hole is blocked in any way, the amplifier will shut down after about 1 minute. The purpose of the switch is to prevent the amplifier finals from overheating if there is no blower air. Not all versions of the manuals and schematics will show this modification. I have seen several sets not work because the owner put the amplifier on a flat surface, using the long separation cable, or painted over the small hole. If you use the separation cable, let the amp sit on its mounting pegs and there will be no problem. When testing on the bench, placing the chassis on a flat surface will also shut down the amp as the air flow is blocked so put something underneath the chassis to lift it up a bit. There is also a thermostat, which will shut down the amp, if the set overheats for other reasons.

If you believe the amplifier is working but you can't get the tune and/or load meters to center, there are several possibilities but we will discuss the two items you often find. First, you MUST follow the tuning procedures in the operators' manual. This is the number 1 operator error and the cause of many destroyed amplifiers in the military and amateur installations. Some will argue that you should tune for maximum power out and ignore the meters however this is a sure way to ruin your amplifier. So, a brief tuning description; pre-set the tune and load counters by the chart on the amplifiers front panel, every time you change bands. Then, switch to "tune" and adjust the control that has the most meter deflection followed by the other control. Often, you have to adjust both at the same time to get a proper indication. If you run out of adjustment and you still do not have centered meters, assuming your antenna is not at fault, it is often the vacuum variable is defective or the 2A4 discriminator module. Either one requires replacement as the vacuum capacitor is not repairable and the discriminator is difficult to test in the chassis. The discriminator is located under the antenna coupler to the right rear



In the 2A1 front panel is the main power supply for the amplifier, the DC-DC converter. This supplies the low and high voltages for the 2A8 driver and the final tubes. In this converter, there is a pair of large high current stud mount transistors in a multi-vibrator circuit. These are usually, but not always, 2N5250's. The transistors often fail if a serious fault occurs in the amplifier, or high temperatures occur due to a blower failure or air restriction. If improper tuning is continuously used, these transistors may not last as the over current protection is not fast enough to prevent surges. Replacing these is not the easiest thing you will ever do but it is possible as I have replaced several. The manuals will guide you through disassembly of the front panel and transistor location. A bigger problem is finding replacements as they are obsolete and only available in large quantities from commercial suppliers. When the transistors were replaced in the depot, both were replaced but in my experience just exchanging the defective one worked fine as long as it is the same type. If one of these transistors failed, the 2A1A5A2R1 and R2 current limiting resistor for the associated transistor may also be defective so check it too.



Inter-unit tuning and interlocking problems will cause the amplifier to just sit there and fail too much of anything. It may start up but won't go beyond showing meter indication in the PRIM VOLT switch position. Everything must be in proper

alignment including both the RT and amplifier turrets, antenna coupler switches and several relays. If anything is not as it should be, the amplifier is disabled to prevent damage. Rotary switches under the turrets and in the coupler can fail, as well as the “dog bone” interconnect cable or connectors. Troubleshooting this situation requires the manual and the interconnect drawing and then tracing things out.

Some less common items to fail include the main circuit breaker not resetting, shown in Figure 7, the “whip/50 ohm switch” on the 2A1 front panel, the power relay 2A1A2K1, defective “tune and test” meters, and the 2A7 relay module. Zener diodes 2A1A1VR1, VR2 and VR3 also have a high failure rate due to the high voltage and heat sinking.

There are of course many more things that can go wrong with your amplifier but these are the ones most often seen.

So, if you have a non-working AN/GRC-106 set, get it out and get it on the air! We’ll see you on the popular mil-rad frequencies!

Ronald L Boltz
K3TZJ
619 Green Springs Road
York, PA 17404
rboltz@rattrig.com