Modifications. (Not)

The only "modifications" needed to a Command transmitter are simple and 100% restorable.

1. Replace the three capacitors in the bathtub on the back. Even if you think they're good, they're bad. Trust me on this. Leakage in this bathtub cap causes big headaches, and if it isn't leaking now, it will be.

Here's an easy way: Unsolder the leads of the bathtub cap, leaving the wires intact. Make sure multiple wires stay connected to each other, just not the cap. Coat them with insulation. "Liquid Tape" by GC is good and available at most electronics parts places, or just use tubing. Leave the wires where they are as their distributed capacitance is part of the design. Get some of those little Mylar .047s from the parts house. They're about the size of a pencil eraser. Trace the wires from the bathtub to where they connect, then solder the cap between there and the nearest ground.

2. Unsolder one lead from the antenna relay. Roll the spring contact from the loading coil around so it's always in contact. Either put some Cramolyn on this contact or polish it as detailed below.

3. Check the selector relay and make sure that the osc. B+ contact (the "short" one, nearest the coil) makes before the 1625 cathode contact. Carefully bend them to make sure. You key the rig with this relay through it's contact on the back plug-it's called the "selector." Put a "spike killer" diode across the relay coil winding (anode to positive voltage lead) to keep the inductive kick off the filaments and keying leads.

That's it. All the hole-drilling and output hacking and "de-TVIing" of the 50s and 60s was completely unwarranted.

If you want to make it easy to tune and remove a source of possible "chirp," the next steps are some work, but well worth the effort-

All the roller coil assembly metal parts (less screws) are plated in silver. This gets oxidized (that black stuff). When you're loading the rig, you'll notice "intermittent" power out as you roll over the gunk. If your loading point is cruddy with this black stuff, it will heat when you key and change the loading enough to introduce some chirp (yes, believe it or not).

Go to Wally World and get some cream silver polish. Don't waste your money on the "dip" stuff. Put a towel or other "parts catcher" on your bench. Completely disassemble the roller coil unit. Pay close attention so you can get it back together in the right order. The leaf-spring contact on the coil axle (ceramic support end) needs to go back right-side-up, so you might want to mark it or just notice how it goes back in. Use a linen or other lint-free cloth to polish the coil, roller bar, roller, axle leaf spring contact etc. Use a "Q" tip to polish the inside of the roller wheel as well. Once all the crud is polished away, rinse off all the polish with clean water and allow the parts to completely dry - especially the coil. Don't want water under the turns.

As you reassemble, lubricate the thumb-wheel end and thumb-wheel axles with petroleum jelly or graphite. Do not lube the ceramic-to-coil joint, but do lubricate the roller coil axle and leaf-spring contact with paste Cramolyn or other good contact lube. Be careful not to overtighten the screws that are threaded into the ceramic. Just finger-tight them and lock them in place with some paint or fingernail polish. Seal the roller-bar screws with paint as well. Now enjoy easy tuning.

On "chirp-" This is a classic MOPA rig. While you can expect some small amount of chirp, I've got many transmitters in which it is difficult to hear any at all. I've never had one that, after I finished restoring it, had what I call "bad" chirp. Noticeable chirp in an "ARC-5" transmitter can usually be traced to a few sources. Here they are in order of their usual appearance:

1. Poor power supply regulation. Your supply needs guts enough to maintain 500-600 VDC at 200 mils and 24 VDC at about 2.5 amps. (if you don't want to use DC on the fils, put a diode and filter cap at the relay)

2. Leaky bathtub caps. Reduces osc. drive, messes with Osc B+, reduces grid bias to the 1625s. See above.

3. Cruddy output tuning network or antenna connections. Anything that changes the loading- like heating the crud between the roller and coil is going to pull the freq of an MOPA rig.

3. Low under-load emission in the 1626 Osc. Swap it out with a known-good one.

4. Grid emission in one or both 1625s. Especially noticeable in one that's been run at 800+ volts. Swap with known good ones.

I've seen changed resistor values in the osc. stage and misc. other stuff, but these four are the usual bandits. While I've heard of the other mica caps going bad, I've worked on many dozens and never seen it happen. I've also never seen that custom "button" cap in the MO stage go bad.

Question: I don't think I've (knowingly) ever heard an ARC-5 CW note. What do they sound like, say on 80 m? I think I remember reading somewhere that they don't always chirp...

I have a first W.E. run contract 1570-NY-41 BC-459, operating as originally designed, with no chirp. It is also the most frequency stable of my 459s. Some later sets have a slight chirp.

Chirp in the ATA/274N/ARC-5 transmitters can have several causes:

1. If keying with the selector relay (the one on the side wall and the best way to do it), be sure the oscillator set of contacts makes before the PA set of contacts. You can gently bend them to accomplish this.

2. Leakage in the 3 x .05 bathtub cap on the back skirt. This will pull the oscillator, change bias on the PA, etc. The leakage in the caps is not constant. It is proportional to time, the voltage across the cap, and the increase in internal temperature as heat is dissipated in the leakage.

3. Oxidation on the loading coil/link rotor contacts. Heavy oxidation between the contacts on these components heats up when you key the rig. This causes a slight change in antenna loading over the fraction of a second of the keying pulse. Any change in antenna loading in an MOPA rig will show up as an impedance change reflected all the way back to the oscillator, causing chirp. I'll post a procedure to clean this up. It's an afternoon's work, but the results are worth the effort.

4. Grid emission or other damage in the 1625s. Some hams ran these radios with plate and screen voltages in excess of specs, then mistuned them by trying to run them directly into 50-ohm antennas, which they are *not* designed to feed (more info on this if interested). If you have any doubt, put NOS 1625s in the rig.

5. Poor power supply design. The supply needs to be able to deliver B+ voltage at 300 mills without going "wobbly." Pick a voltage somewhere between 400 and 550 volts, then build a

supply that can "keep it up." Same with the filament voltage; it should not degrade with keying, assuming you are using the relays.

In the original design, the "selector" relay and the antenna relay were activated to "select" the transmitter to be used. Keying happened in the modulator unit, where the B+ main was keyed by a relay. The "selector" relay (the one under the chassis) applies B+ to the oscillator and grounds the PA cathodes. So, by happy chance, it makes an excellent "keying" relay for those folks who do not have the entire set-up.

1. How was it keyed originally?

In the original design, all B+ voltages were supplied by a dynamotor which provided 550 VDC with good regulation. Screen and Oscillator voltages were developed with a resistive divider network. The transmitter was keyed by a relay making and breaking the 550 VDC output of the dynamotor. Believe it or not, with a properly operated (as in "operated as designed) transmitter, there is little chirp with this system.

I do not recommend the usual mods you see in the ARRL or "conversion" handbooks. They key badly, tune incorrectly and offer other frustrations. Running the filaments on 12 VAC introduces hum in the master oscillator output and impacts overall frequency stability. You can buy 24 volt power supplies that will deliver a regulated 3 or 4 amps from surplus dealers for a few dollars, so there's no good reason to destroy the filament string and hack out the relays; you gain nothing and lose system stability.

2. How do you key the transmitter?

Pin #5 on the SCR-274N and ATA transmitters and pin #3 on the AN/ARC-5 transmitters keys the transmitter select relay and the antenna relay. With a lead lifted on the antenna relay and the contacts on the selector properly sequenced as I wrote in one of the posts, it works splendidly as a keying relay. I've run my bug at 25 WPM with no trouble.

3. They suggest adding a coax connector for the antenna.

Ill-advised and needless. The "ARC-5" transmitters cannot match a coax-fed, 50-ohm antenna in their native state. The simplest fix (not perfect, but it will work just fine) is, as I wrote before, to put a 1000 volt or better, NP0 type capacitor in series with the output lead, then connect that to your coax feedline. Something around 50 pFd will work best at 7 MC, something between 75 and 125 pFd on 3.5 MC will do. There's a lot of "wiggle room" on these values, unless you want to get it perfect. Marty's suggestion of a large variable in series will work, too. And Mike's UnUn will also do the job, and is my personal preference.

4. Were some hams in the 50s simply connecting their antenna wire to the original terminal?

Yes; they hooked 50-ohm antennas to the output, mistuned it to get as much power out as they could with the serious mismatch and got pink tickets for harmonics, just exactly as you would if you mis-tuned any other transmitter's output and used it. Tune the transmitter properly and it's cleaner than many modern transceivers.

5. What would be the most effective and simple antenna that one could use now, to avoid what seems like complexity as indicated in the discussion we are currently having?

Kindly speaking, I don't think a series cap is all that complex. You could use a short, end fed wire or "T" as they did on the body of the aircraft, and the transmitter will tune it without any changes at all. You won't get much in the way of signal out, though.

6. I assume that one would need to add a good grounding terminal to the unit. Cannot say I understand how that was done in the airplane, but for ham use, I assume those who are using these units are grounding the chassis to a good earth ground. Does this not mean adding some kind of a terminal lug to this chassis?

In the original design, the transmitter was one part of a larger system. It fit into a mounting rack which road on a shock mount. The ground lead ran from the mounting rack to the aircraft body right at the mount. No need to drill a hole to ground your transmitter; unscrew any of the screws and use it to attach a ground lug at that location.

And I strongly recommend using DC on the filaments, even if they have been rewired for 12 volts. Don't listen to any advice about "de-TVI-ing" or output tuning in any of these articles; they are universally in error. Use the techniques for antenna tuning we've discussed.

Harmonic Output and Why.

I made the measurements following this discussion in 1996 using several transmitters. I used then-state-of-the-art spectrum analysis equipment borrowed from Uncle Sam in Nevada for the purpose. I tested the rigs into resistive and reactive loads, running them straight-through, with a series capacitor, with an Un-Un and with combinations thereof. While the exact figures are buried somewhere in storage, I can provide a summary: When operated as they were designed into either resistive or design-tunable reactive loads, the transmitters are exceptionally clean, with excellent harmonic attenuation and no significant HF or VHF spurs - all the anti-TVI flailing around and hack-sawing was complete folly.

When tuned as the average ham of 1950 did - loading coil at zero, link at 100% - harmonic attenuation was severely reduced, especially of the third harmonic IIRC, though never less than 20 db down from the fundamental. I don't doubt there were some pink tickets for that. However- even in the mistuned state, there were NO significant HF or VHF spurs radiated from any transmitter. I think all those "ARC-5 TVI" reports had more to do with poor TV front ends and 21 MC TV IF strips than the transmitters.

One exception - I also did measurements on the ARC-type-12 transmitters, although only into a 50-ohm resistive load. These rigs double in the final and there is a very significant .5Fo peak in the output when fed to a dummy load. At 144 MC Fo, the 72 MC peak was only about 3 db down, which seems a shame to waste that power, but perhaps the costs of better selectivity was a factor. I assume the designers meant the antenna to be the final selective element.

Well, I'm no EE and am not qualified to talk about conjugates; I thought that was what prisoner's got when their wives came to visit. I made an effort to find those figures from the work I did in 1996. I managed to find one page, covering tests with a T-22 at 7 MC and a T-19 at 3.5 MC.

I don't remember the name of the test equipment, but I set the fundamental as a zero-reference and read harmonics in dbm relative to the fundamental. IIRC, anything -80 dbm or more below the fundamental was in the noise floor of the test set. It may have been better, but I haven't found the page that had the set-up data; -80 dbm is my best recollection.

Load was 50-ohms resistive.
The ARC-5 was set up 100% "as designed," with modulator/dynamotor/racks/antenna relay etc. I used the 50-pFd series vacuum cap provided with the antenna relay.

All tests were made with the transmitter in "VOICE" mode to lower the power levels-Remember, these were plate modulated AN/ARC-5, so you can tune up in VOICE, unlike the 274Ns which must be tuned in "CW" mode.

I made tests with combinations of the series cap, an UNUN 1:4 auto transformer and with no external antenna tuning elements ("50's ham" tuning). I made no attempt to use a variable cap, which would have provided a better match and allowed more power out. I was interested in harmonic suppression, not power. I never got back to the tests to
find the "correct" matching cap for 7 and 3.5 MC. I'm sure getting the cap closer to "correct value" would have made the harmonic rejection even better, but these figures were good enough for a first illustration, which was all I was trying to do.

I don't attempt to explain the numbers-I just report them. I'll leave explaining to the multitudes of people brighter than me on this subject.

T-19 Trans.,
3500 KC.
No Cap,
No Xfmr.
Ep 550 V / Ip 75 ma / Iant unreadable
Loading coil 0% / Ant. Coupling 100% / Pout 18W
2nd Harm -30 dbm / 3rd Harm -41 dbm

T-19 Trans., 3500 KC, With 1:4 Xfrm and Series Cap 50 pFd
Ep 540 V / Ip 90 ma / Iant 1.5 A
Loading Coil 70 % / Ant. Coupling 65 % / Pout 17W
2nd Harm -46 dbm / 3rd Harm -58 dbm
(obviously need a bigger value cap here).

T-19 Trans., 3500 KC, With Series Cap 50 pFd (No xfmr)
Ep 545 / Ip 85 ma / Iant .2 A
Loading Coil 70% / Ant. Coupling 55% / Pout 22W
2nd Harm -50 dbm / 3rd Harm -50 dbm

The sheet is torn, so I'm missing the tune-up
date for "Transformer, but no Cap,"
but the important figures are still here:
2nd Harm. -30 dbm / 3rd Harm. -44 dbm

On to 40 meters...

T-22 Trans., No Xfmr and No Series Cap.
Ep 550 V / Ip 55 ma / Iant unreadable
Loading Coil 0% / Ant. Coupling 100% / Pout 6W
2nd Harm. -40 dbm / 3rd Harm. -60 dbm

T-22 Trans., With Xfmr, No Series Cap
Ep 545 V / Ip 90 ma / Iant 1.25A
Loading Coil 45% / Ant. Coupling 70% / Pout 16W
2nd Harm. -56 dbm / 3rd Harm. -64 dbm

T-22 Trans., With Series Cap, No Xfmr
Ep 575 V / Ip 80 ma / Iant 0.2A / Pout 20W
Loading Coil 45% / Ant. Coupling 90%
2nd Harm. -55 dbm / 3rd Harm. -62 dbm

(Data with both missing)

Please note that, with every transmitter tested, beyond the 3rd harmonics, I found no, nada, none, zip-any spurs or harmonics strong enough to peek up out of the -80 noise floor all the way up to 1 gHz.

On an ARC-5 Power Supply:

First- there are three "flavors" of transmitters commonly lumped under the name "ARC-5" The first is the Navy ATA, second is the Army SCR-274N and last is the Navy AN/ARC-5. The rear connectors and wiring for the ATA and SCR-274N rigs are identical. The AN/ARC-5 connector is physically different and the wiring is also somewhat different. If your transmitter is black wrinkle painted and has a big RF choke next to the tank coil, it's AN/ARC-5. If it's black and has not such coil, but has an anchor in yellow paint on the back skirt, it's an ATA. If it's silver, it's a later SCR-274N. If it's black, has no RF Choke and has a "BC-4xx" number on the back skirt, it's SCR-274N.

Transmitter Plug Pin-out:
(Note: If yours has an octal socket or anything other then the 7-pin Mica connector, then it's a modification and all bets are off.)

For AN/ARC-5-
There are seven pins. The pin in the center is pin #7. Locate the pin that is grounded to the chassis. This is pin #4. Count the others *clockwise* around accordingly.

1. No Connection
2. +200VDC for the Osc. (needs to be right for stability).
3. Keying Relay (ground to key).
4. Ground.
5. A+ 24-28 VDC.
6. PA Screen Voltage (use 20K 5W dropping res. from B+).
7. PA Plate B+ Voltage +550VDC

For ATA/ARA and SCR-274N:
There are seven pins. The pin in the center is pin #7. Locate the pin that is grounded to the chassis. This is pin #1. Count the others *clockwise* around accordingly.

1. Ground
2. Test point for PA grid current.
3. +200VDC for the Osc. (needs to be right for stability).
4. PA Screen Voltage (use 20K 5W dropping res. from B+).
5. Keying Relay (ground to key).
6. A+ 24 VDC.
7. PA Plate B+ Voltage +550VDC.

The best way to get power to the rig is the way the original engineers intended. I don't mean a dynamotor- I mean a good, solid 550 VDC source and a divider. Both the AN/ARC-5 and SCR-274N units derive their voltages using a voltage divider network. We'll draw a divider that matches the one used in the original power supply. I very much recommend it.

Primary power should be 24-28 VDC at about 2.5 amps for relay and filiments and B+ of 500-600 VDC at about 200 MA. We will assume the designer's specs of 550 VDC B+ and 26 VDC filament. Get a pencil and a piece of paper. Follow along:

Place a dot on your paper and call that point "A".

Draw a line right to point "B".
From point "B", draw a line down and connect a 20 K-ohm, 5 watt resistor here. Call the other end of this resistor point "C".

Draw a line right from point "B" to point "D".

From "D", draw a line downward and connect a 15 K-ohm, 10 watt resistor. Call the other end of this resistor point "E".

From point "E", connect a 100 K-ohm 1 watt resistor to ground.

Draw a line right from point "D" to point "F".
Draw a line right from point "E" to point "H".

+550 VDC in at point "A".
+550 VDC out to PA plates at point "F".
+270 VDC out to PA screens at point "C".
+200 VDC out to Oscillator at point "H".

Bypass all outputs with about .01 ufd to ground.

If you wish to regulate the screens for AM, connect an 0D3 VR tube with a .5 ufd at 300VDC cap across it between point "C" and ground. This will bring the screen down to 150 volts.

If you use this network, and use correct antenna matching, you will be able to properly load and tune your command set transmitter to rated output.

Voltages lower then 550 VDC will work just fine with the same network. Voltages much higher will cause MO drift and increase chirp.

The voltage fed to the 1626 oscillator should be no more then 200 volts. Yes, I know the AN/ARC-5 manual say the plate will test about 230 volts in the original setup. Nevertheless, higher values can cause drift. Lower values reduce oscillator output. Since the bias on the 1625s comes from the oscillator output, it needs to be "right," or at least proportional to the high B+. If you run 400 volts on the final, 180 volts on the oscillator will probably work OK.

The original design uses a voltage divider network to derive screen and oscillator voltages from the 550 volt B+. This is still the best way to do it. The oscillator stage is very stable if the bathtub caps are replaced and the voltage is right. A properly operating 1626 oscillator with 200 volts supplied will draw around 20 milliamps. An exception is the AN/ARC-5 T-18 2.1-3MC transmitter. Its oscillator will draw around 18 mils.

If you're going to run AM, regulate the 1625 screens down to 150 volts with a VR-150 bypassed with .5 μfd. Connect it between the screen voltage lead and ground. The screen divider resistor will also current limit for it. If you screen modulate, you must tune the transmitter to full output on CW before switching in this regulator.

On Loading an Antenna:

The SCR-274N and AN/ARC-5 radios were not designed to load a 50 ohm antenna. They were intended for antennas of about 5-12 ohms. In order to load a 50-ohmer you'll need to do one of two things:

Cheap and easy- put a good quality NP0 (no thermal drift) capacitor of at least 1000 volts between the antenna terminal and the coax center conductor (in series). For 40 meters, use 50 PF. For 80 meters, use 75 PF. Non-NP0 caps may heat, drift and cause chirp.

More trouble but better: Wind a 4:1 "UNUN," which is an unbalanced to unbalanced balun, and use it at the antenna connector to match the coax. The design is available in the Handbook. Will cost a couple of watts but is worth it.