

Welcome to Restoring Antique Radios: The 1931 Cathedral Philco Model 20



73's From **AD5XR**

Formally KA6DLZ & WD4JPL



First QSO, August 7, 1977

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HF Equipment
ICOM IC-718
Yaesu FT-101E
Hallicrafters HT-37
Collins R-390A
Homebrew Amp
Carolina Windom
5-band Vertical

Thanks _____
For the contact
from: _____
Signal: _____ Mode: _____
Time: _____ z
Date: _____
Frequency: _____

Grid: EM42xh, Coordinates: 32° 17' 37" N, 90° 0' 46" W. Please QSL _____ Tnx _____
Mobile rig is a Yaesu FT-857D with a Comet HV-6, tuned for 7 bands Mobil _____ Fixed _____

Before you start, you must have a clean, well organized work space



The first steps in restoring and/or repairing an antique radio

Find information on the set if possible before starting

The Boat Anchor Manual Archive (BAMA)
(<http://bama.edebris.com/manuals/>) is a great site to find service manuals and schematics

Always resists the urge to plug it in and see if it works

Something as common as a sorted rectifier tube could burn out your power transformer. Remember, let that smoke out and they won't work.

Test all tubes before you plug it in.

There are local Hams that have tube testers and will help you.
If nothing else, check for shorts and filament continuity with an Ohm meter

If at all possible, study the schematic and write a simple point-to-point test procedure.

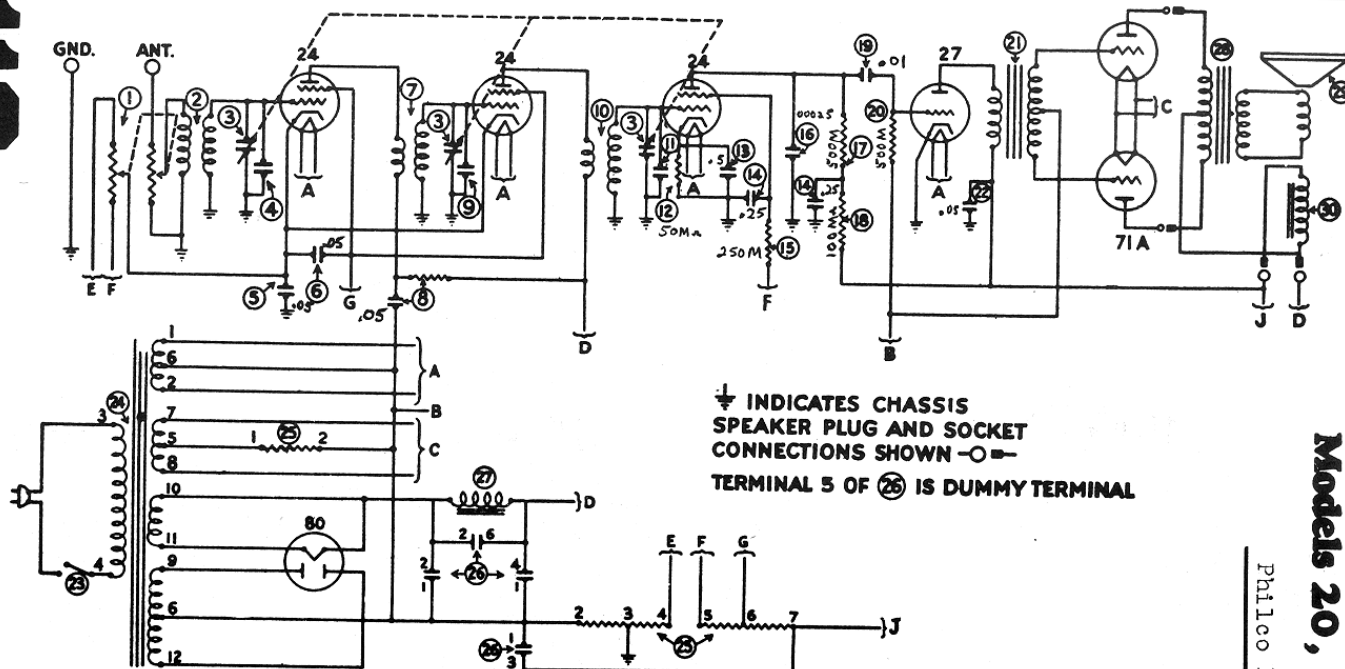
Don't electrocute yourself!



Download a Schematic of the Radio Your are Restoring

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COMPILED BY M. N. BEITMAN, SUPREME PUBLICATIONS



No.	Description	Part No.
①	Volume Control	4094
②	First R. F. Transformer	3884-N
③	Tuning Condenser	4200-A
④	First Compensating Condenser (Part of Tuning Condenser Assembly)	
⑤	By-Pass Condenser (.05)	3615-J
⑥	By-Pass Condenser (.05)	3615-M
⑦	Second R. F. Transformer	3884-P
⑧	By-Pass Condenser (.05) and Resistor	3615-K
⑨	Second Compensating Condenser (Part of Tuning Condenser Assembly)	
⑩	Third R. F. Transformer	3884-P

⑪	Third Compensating Condenser (Part of Tuning Condenser Assembly)	
⑫	Resistor (50,000)	4237
⑬	By-Pass Condenser (.5)	3583
⑭	By-Pass Condenser (double .25)	3557
⑮	Resistor (250,000)	3768
⑯	By-Pass Condenser (.00025)	3082
⑰	Resistor (500,000)	3769
⑱	Resistor (100,000)	3767
⑲	Condenser (.01)	3903-F
⑳	Resistor (500,000)	3769
㉑	Push-pull Input Transformer	4232
㉒	By-Pass Condenser (.05)	3615-L
㉓	On-off Switch	4095

㉔	Power Transformer (50-60 cycle)	4234
㉕	Power Transformer (25-60 cycle)	4268
㉖	B. C. Resistor	4230
㉗	Filter Condenser (50-60 cycle)	4235
㉘	Filter Condenser (25-60 cycle)	4269
㉙	Filter Choke	4231
㉚	Push-Pull Output Transformer	2766
㉛	Voice Coil and Cone	2769-B
㉜	Field Coil	2768

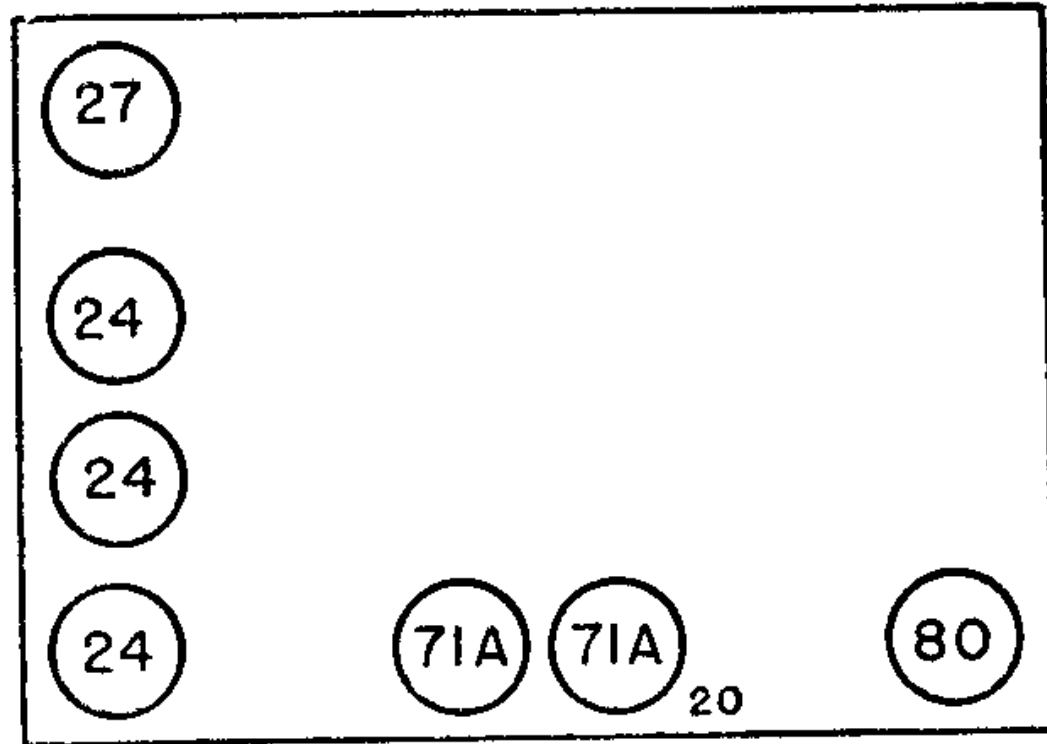
MANUAL OF MOST-OFTEN-NEEDED RADIO DIAGRAMS

Models 20, 20-A and 21

Philco Radio

Tube Placement Chart

MODEL 20 →
MODEL 220 →



80 tube, subs
are 5Z3 & 83



24 tube, subs
are 35 & 51



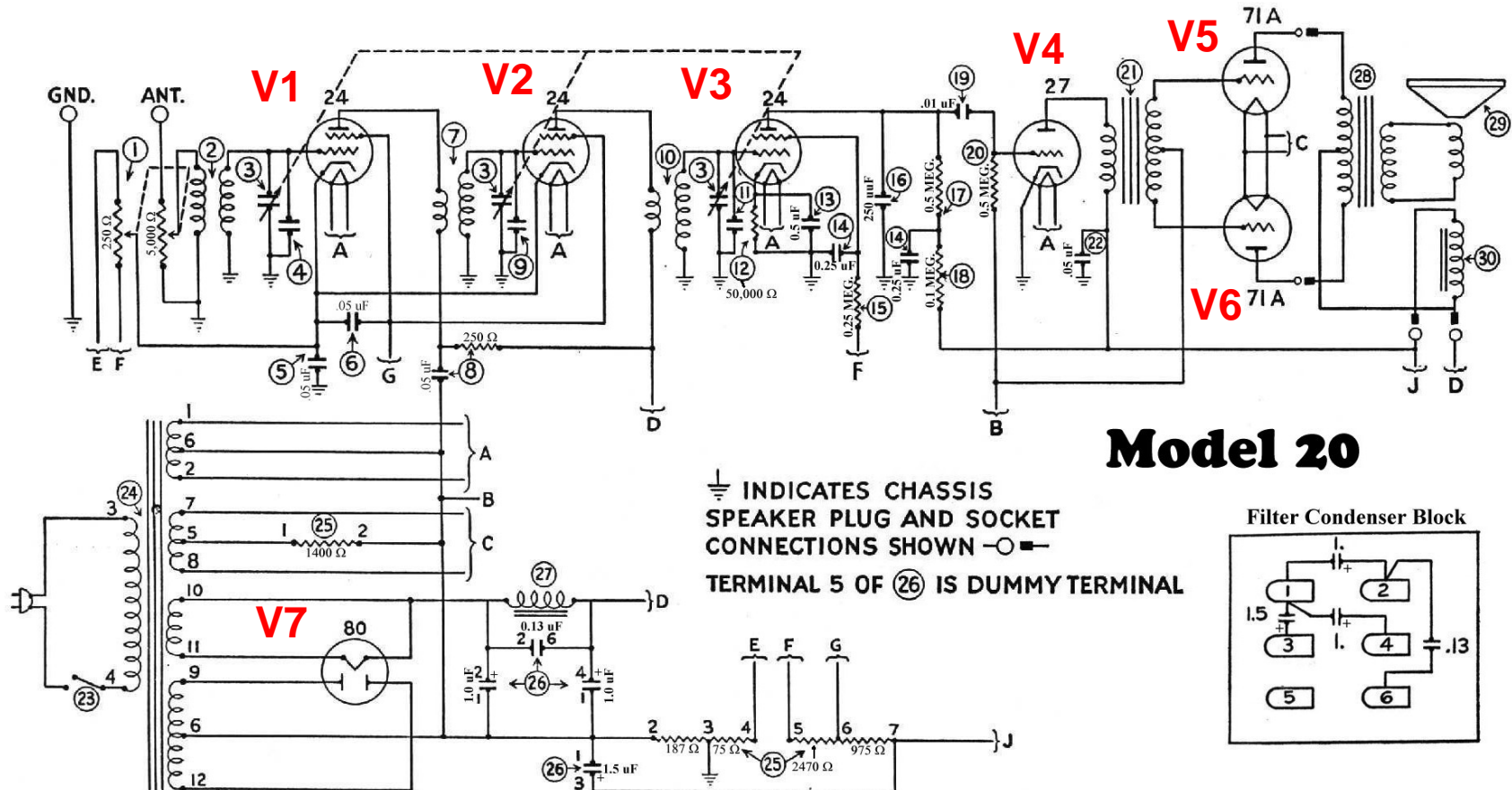
27 tube,
sub is 56



71A tube,



Because the schematic did not include tube pin numbers, I added the pinouts from the web along with substitutes.



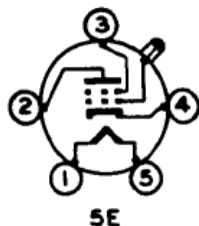
1.Power Transformer Pre-turn On Tests

Condition and comments	From	To	Calculated value	Measured Value	Pass Fail	Repaired Value If Required
AC filament winding	T1-1	T1-2	TBD	0.2Ω		
	T1-1	Chassis ground	>187Ω	2.3Ω	X	
	T1-2	Chassis ground	>187Ω	2.5Ω	X	
	T1-6	Chassis ground	187Ω ±10%	1.8Ω	X	
DC filament circuit	T1-7	T1-8	TBD	0.3Ω		
Chose the lowest reading	T1-7	V5-1 or V5-4	<1Ω	0.2Ω		
Chose the lowest reading	T1-8	V5-1 or V5-4	<1Ω	0.2Ω		

Pre-power Up Resistive Test
1.Input Tests

Condition and comments	From	To	Expected value	Results	Pass Fail	Repaired Value If Required
Volume control set to MAX	Antenna input	Chassis ground	$>10\Omega$ $<30\Omega$	24.5Ω		
Volume control set to MIN	Antenna input	Chassis ground	$>1\Omega$	∞	X	
N/A	Antenna Ground Input	Chassis ground	$>1\Omega$	0.5Ω		
ON/OFF switch set to ON	One side of the AC input	Chassis ground	$>1M\Omega$	∞		
ON/OFF switch set to OFF	One side of the AC input	Other side of the AC input	$>1M\Omega$	∞		
ON/OFF switch set to ON	One side of the AC input	Other side of the AC input	$< 100 \Omega$	5.6Ω		

24 tube, subs are 35
& 51



1.RF Amplifier Tests

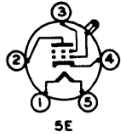
1. For this test remove all tubes from their sockets. All references to tubes (V) refer to the tube's corresponding socket.

1. All grid cap readings will be very low and will mask a shorted resonating capacitor. These are shown in the original schematics as numbers 3, 4, 9 and 11.

Condition and comments	From	To	Calculated value	Measured Value	Pass Fail	Repaired Value If Required
V4 detector tube type 27 plate circuit	V4 - 2	Speaker socket - 4	TBD	911K		
V4 detector tube type 27 grid circuit	V4 - 3	GND	500K Ω $\pm 200\Omega$	650K		
V4 detector tube type 27 cathode circuit	V4 - 4	GND	<1 Ω	2.7 Ω	X	
V4 detector tube coupling capacitor test	V4 - 3	U3 - 2	>0.6M Ω	855K		
V4 detector tube filament circuit. Chose the lowest value	V4 - 1	Power transformer - 1 or 2	<1 Ω	0.1 Ω		
V4 detector tube filament circuit. Chose the lowest value	V4 - 4	Power transformer - 1 or 2	<1 Ω	0.1 Ω		

1. Detector and Audio Driver Tests

24 tube, subs
are 35 & 51



27 tube,
sub is 56



Condition and comments	From	To	Calculated value	Measured Value	Pass Fail	Repaired Value If Required
V4 detector tube type 27 plate circuit	V4 - 2	Speaker socket - 4	TBD	911K		
V4 detector tube type 27 grid circuit	V4 - 3	GND	500K Ω $\pm 200\Omega$	650K		
V4 detector tube type 27 cathode circuit	V4 - 4	GND	<1 Ω	2.7 Ω	X	
V4 detector tube coupling capacitor test	V4 - 3	U3 - 2	>0.6M Ω	855K		
V4 detector tube filament circuit. Chose the lowest value	V4 - 1	Power transformer - 1 or 2	<1 Ω	0.1 Ω		
V4 detector tube filament circuit. Chose the lowest value	V4 - 4	Power transformer - 1 or 2	<1 Ω	0.1 Ω		

1. Detector and Audio Driver Tests cont.

Condition and comments	From	To	Calculated value	Measured Value	Pass Fail	Repaired Value If Required
V4 detector tube filament circuit. Chose the lowest value	V4 - 1	V4 - 5	<1Ω	0.1Ω		

1.Audio Circuit Tests

Speaker Plug looking at the pins

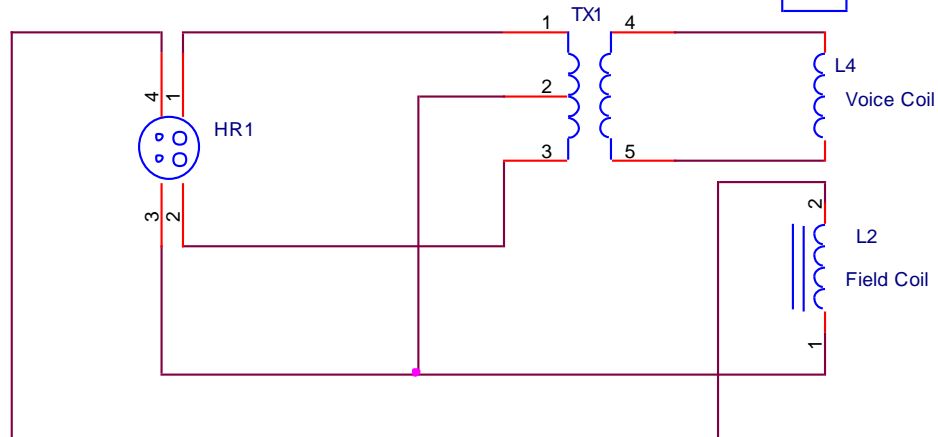
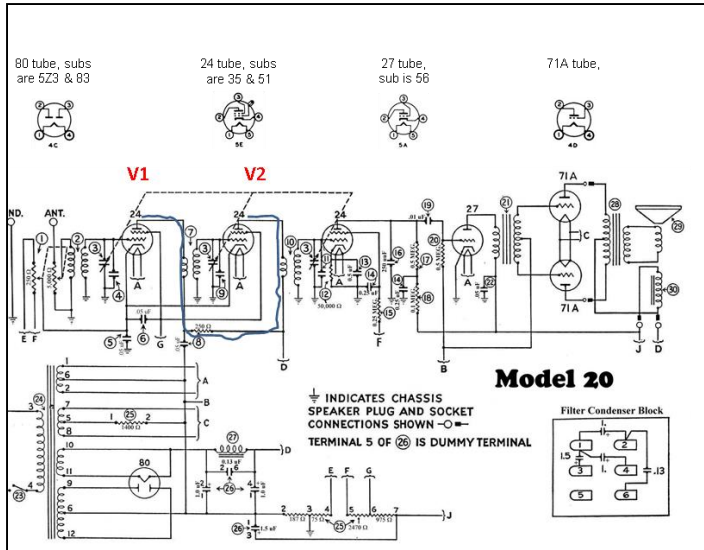


Figure 1. Speaker Plug Circuit

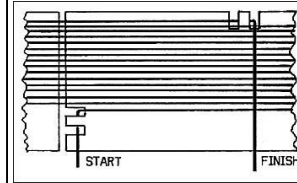
Example of failures detected from test procedure

Power Transformer Pre-turn On Tests (example of faults found, shorted filament winding on power transformer)

Condition and comments	From	To	Calculated value	Measured Value	Pass Fail	Repaired Value If Required
AC filament winding	T1-1	T1-2	TBD	0.2Ω		
	T1-1	Chassis ground	>187Ω	2.3Ω	X	
	T1-2	Chassis ground	>187Ω	2.5Ω	X	
	T1-6	Chassis ground	187Ω ±10%	1.8Ω	X	
DC filament circuit	T1-7	T1-8	TBD	0.3Ω		
Chose the lowest reading	T1-7	V5-1 or V5-4	<1Ω	0.2Ω		
Chose the lowest reading	T1-8	V5-1 or V5-4	<1Ω	0.2Ω		



Early Philco radios up to around 1932 used a novel method of winding the RF coils. The secondary coil of enamelled copper wire was wound directly on the form in solenoid fashion. A plastic strip was wrapped over the cold end of the winding and the primary coil of cotton-covered bare copper wire was wound on the plastic strip. The drawing below shows the method.



The strip was made of Celluloid (cellulose nitrate), the only thin plastic available at the time. This clever construction anchored the primary and provided a level surface to wind it on, but had a fatal flaw. No one knew that Celluloid would slowly decompose over the years, especially under warm, humid conditions.

When Celluloid decomposes, it releases nitric acid which rots the cotton cover and eats away the bare wire of the primary. Luckily, the enamel coating protected the secondary wire, so it is usually in good shape. You should routinely check the continuity of early Philco coils and not be surprised to find open primary windings. Even if the coils seem OK, they may be in precarious condition. I have had coils open up after an hour or so of playing.

Bad primaries are easy to rewind. Disconnect the wiring and remove the coil from the set. Carefully count the number of turns on the primary if your model is not one of those in the table below. Don't try to count turns by unwinding; the wire will break and crumble. Count by dragging a pin or needle over the coil surface so you can feel each turn as the pin passes over it.

It's also a good idea to make a sketch of the coil before taking it apart. Remove the primary wire and remains of the plastic strip. Salvage as much of the strip as you can to use as a pattern. Immerse the entire coil in dilute ammonia and rub it gently with a soft toothbrush to remove any acid residue. Rinse it thoroughly with water, and let the coil dry.

The number of turns for three models I have restored are given below:

MODEL	TURNS	WIRE GAUGE
20	55	32
70	69	32
90	100	34

Cut a new plastic strip of the same dimensions as the original with notches in the same places using the remains of the original as a pattern. The plastic used in blister packages is about the right thickness. Unexposed photographic film which has been boiled to remove the emulsion can be used. 32 gauge enamelled



Repair the broken circuits

From schematic to test procedure and results

Google for help information

Condition and comments	From	To	Calculated value	Measured Value	Pass Fail	Repaired Value If Required
Plate circuit	V1 tube socket - 2	V2 tube socket - 2	250 Ω	∞	X	
Plate circuit	V1 tube socket - 2	V7 tube socket - 1	Slightly higher than 250 Ω	∞	X	
Plate circuit	V1 tube socket - 2	V7 tube socket - 4	Slightly higher than 250 Ω	∞	X	

Problems found from the test procedure

From just the test procedure I learned the following:

1. The antenna input/volume control circuit is open
2. The RF transformer between V1 and V2 is open
3. The circuit between V3 pin 2 and V4 pin 2 is open
4. The bypass capacitors are leaky
5. Too much resistance between V3 pin 2 (plate) and ground
(should be approximately 513,695 Ohms)
1. Poor ground on V4 pin 4 (cathode of the 27 tube) reads 2.7Ω

Note: The estimated resistive value of the push-pull audio transformer input was $<100\Omega$, however it measured 5K. Don't know why, but it worked just fine.



“If it is not broke, don't fix it!”

4C

5E

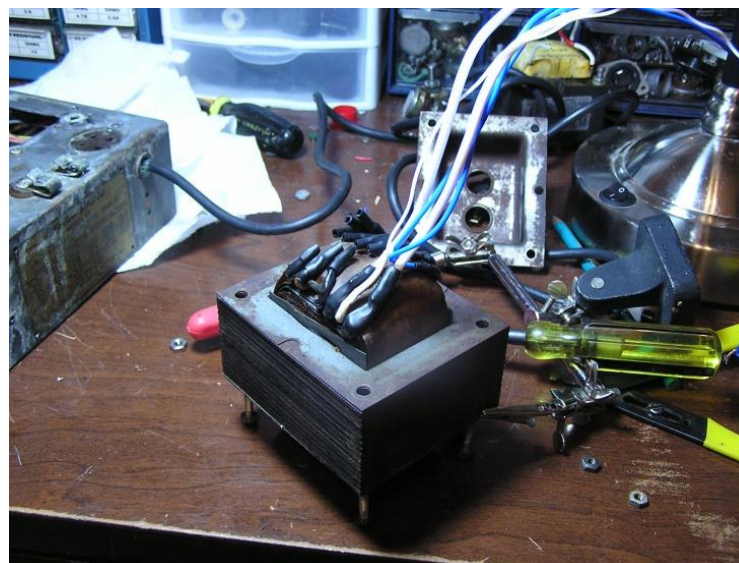
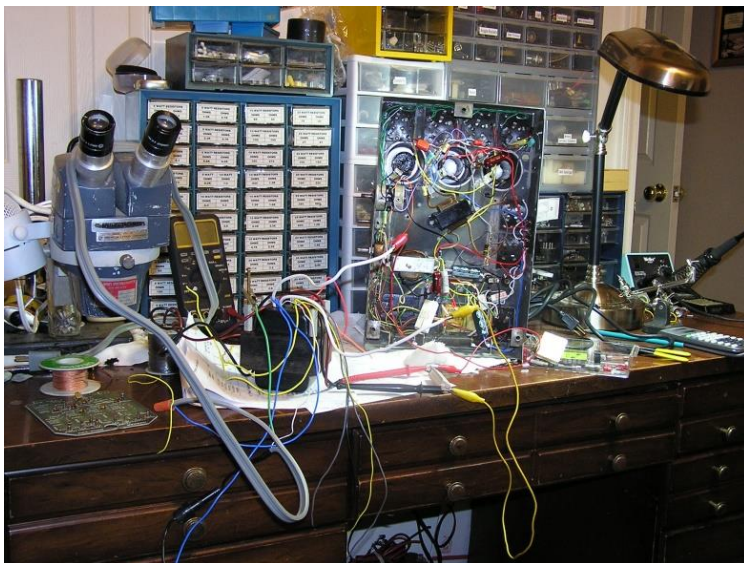
4D



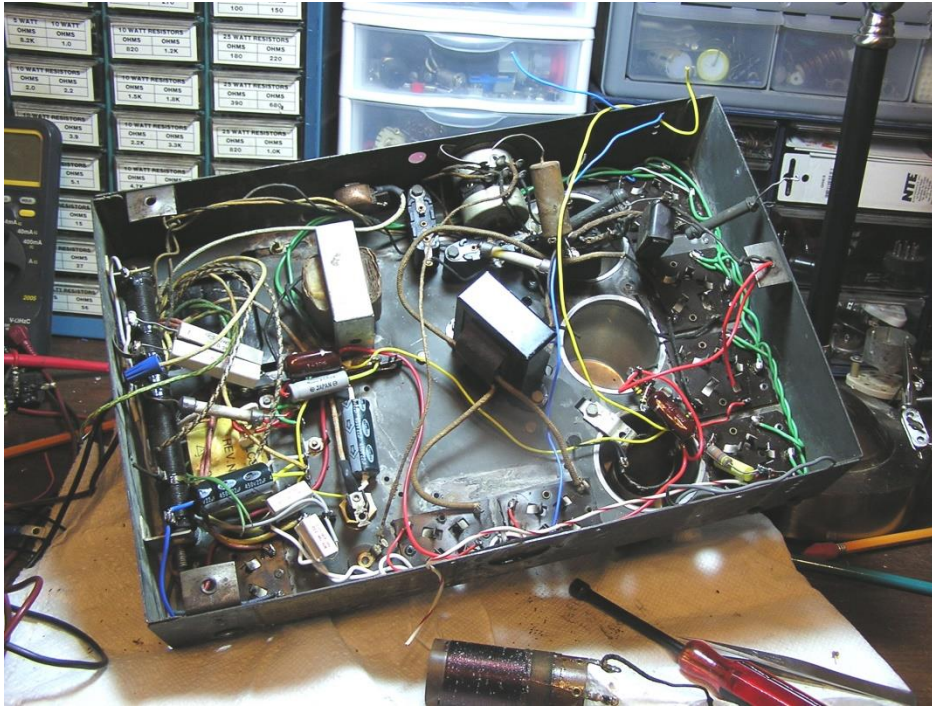
**Sometimes the task are really tedious like
rewinding the RF transformers**



Filament & Power Transformer Rework



After many hours, it is coming together.



Ready to install the RF transformer
Back into its shield



Fully functional chassis
back in its repaired
cabinet.

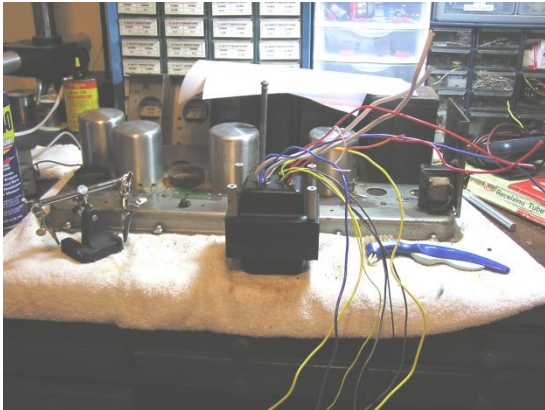
Cabinet Repair



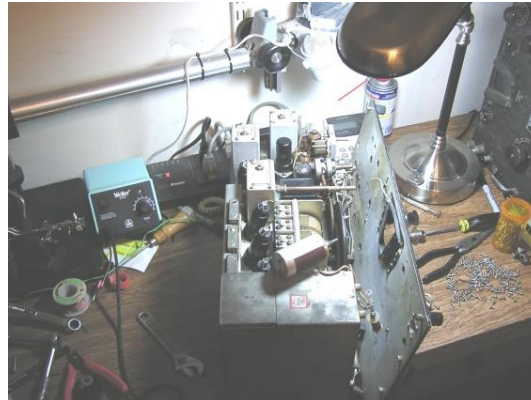
**The time when it is all worth it, TRF radio
playing 89 years after it was made.**



From a commercial radios, to the more challenging military BC342N or the very complex Collins 390A, the procedures are the same. There are simply more steps and circuits in the complex radios.



1920's Atwater Kent



WWII BC342N



Finished WWII BC342N



1939 Philco Mod 40



Collins R390A



**Thanks
for inviting me to speak**

**73's
Wayne Squires AD5XR**