

RECEIVER RCA BC-348

Here I describe the restoration of an American receiver from the second world war (WWII), the RCA-BC348-R. The BC-348 was used in almost all american bomber and reconnaissance aircraft together with the transmitters BC-349 or BC-375. The receiver is wellknown and quite popular among collectors and museums.

I describe the initial condition, the restoration and the result in text and photos.

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RECEIVER RCA BC-348 OVERVIEW

History

The BC-224 and BC-348 receivers were designed by RCA for the American Signal Corps in the later half of the 1930's. More than 100.000 (!) units were manufactured, most of them by Wells Gardner and Belmont Radio, both in Chicago.

The receivers were used in heavy bomber and transport aircraft during the second world war and all through the Korean war, the most wellknown being the B17 "Flying Fortress", the B24 "Liberator" and the B29 "Superfortress". The photos show a B17 on a bomb run and the radio operator with a BC-348 and the J37 key.



The B24J Liberator "Witchcraft" is operated by the Collings Foundation and making summer tours in the USA. The photos below show the aircraft, the cockpit and the radio operators position with a well used BC-348-N made by Wells Gardner. Thanks for the B24 photos to Tom Murphy, San Lorenzo, California. This is the only B24 aircraft still flying!



B17 G Flying Fortress



B24J Liberator "Witchcraft"



Receiver data

The BC-348 and its predecessor BC-224 were used in almost all American and also some British and Canadian bombers and transports as well as in some ground vehicles, from the second world war and 15 years beyond. BC-224-A was developed in the mid 1930's, and after extensive tests an improved version, the BC-224-B, was adopted as a standard by the US Signal Corps. From this B model all BC-224 and BC-348 receivers were built to the same specification and were so similar that most parts were interchangeable, except for the built-in dynamotor for voltage conversion from the aircraft electrical system. BC-224 was built for 14 V and BC-348 for 28 V. Eventually there also were differences in the valve complement.

The receivers were very reliable and easy to maintain. Electrically they remind of the ground receiver AR88 also designed by RCA, but the weight is only around one third of the AR88 weight. The BC-224/348 is a superheterodyne with two RF and three IF stages. In the IF part there is a crystal filter with the positions "Out/In", that is wide/narrow. The versions BC-224 A to D and BC-348 B to C (BC-348-A does not exist) cover 1.5 to 18 MHz in six bands. In the later models the receiver covers the frequency range 200 to 500 kHz and 1,5 to 18 MHz, still in 6 bands. The IF is 915 kHz. The sensitivity is in average 1.2 uV (min 7 uV) for 500 (MVC) – 800 (AVC) mW out. The bandwidth is 7 kHz (+/- 3.5) for @ - 6dB in the higher bands 1.5 – 18 MHz in position wide, 600 (+/- 300) Hz @ - 6dB in position narrow.

Most sets built were of the BC-348-R type, all built by Belmont Radio. These have the valve 6K7 in the RF and first IF stages, 6C5 as oscillator and 6J7 as mixer, 6F7 as second IF / beat oscillator and 6B8 as the third IF / detector stage. The final AF stage is a 6K6GT. All valves except the 6F7 and the 6K6GT are of the metal type. The RF, oscillator and mixer stages are module built with the components in separate shielding boxes.

The models BC-348 J, Q and N were manufactured by Wells Gardner with point to point wiring which had then become an industry standard. They also had the so called "single ended" valve design meaning valves without top connectors. Still the specifications were the same and most parts were still interchangeable with other models.

In the aircraft the receivers were driven by 14 or 28 V over a built in rotary converter, but in many receivers the converter has been changed to a more or less well designed mains driven power supply. The receiver measures 46 cm x 27 cm x 24 cm (w x h x d), and the weight is 16 kg.

My receiver

My receiver is a BC-348-R which I bought on the auction site Tradera. The receiver was sold at a low cost as non-working, when it was tested by the seller a condenser in the filter unit blew. The receiver did not look too good in the photo but I took a chance that it would be fine inside.

My receiver was built by Belmont like all BC-348-R, in 1943 against the order 31414-WF-43 and it has the serial number 612.

The picture shows the receiver in a typical restoration situation, upside down and with the plate covering the RF tube shelf removed. The receiver had been repainted and was a bit too shiny in some spots, but it was very good inside, almost like new! It has the older type of tubes with the top connectors and not the

later "single ended" design. The dynamotor had been replaced by a 220 V power supply, which I find to be an acceptable change for practical reasons! No other modifications were found, but the rotary switch for AVC-OFF-MVC was faulty and replaced with a DPDT switch. The output tube was a 6Y6G instead of a 6K6GT.

As usual the power supply was badly designed, so the first action was to redesign it. It had no safety grounding and no fuses (when will radio amateurs learn about safety???) , and when tested with a dummy load of 70 mA it gave 350!!! V out, the poor receiver is designed for around 220 V. The filtering was very bad, no choke or resistor, only a condenser of 16 uF! The transformer was fine and it fed a nice, classical 5Y3GT. The filament chain had been rewired for 6,3 V instead of the original 28 V and worked well.

More on the condition and the restoration of the receiver can be found in the chapter Restoration, and more photos in the chapter Photo Gallery.

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RECEIVER RCA BC-348-R RESTORATION (March 2007 – October 2009) (DIARY)

Restored unit Belmont BC-348-R built 1943 against order 31414-WF-43 and with serial number 612.
Will be restored to its original state except for the dynamotor.

1. Initial condition

The receiver had been repainted and was a bit too shiny in some spots, but it was very good inside, almost like new! It has the older type of tubes with the top connectors and not the later "single ended" design. The dynamotor had been replaced by a 220 V power supply, which I find to be an acceptable change for practical reasons! No other modifications were found, but the rotary switch for AVC-OFF-MVC was faulty and replaced with a DPDT switch. The output tube was a 6Y6G instead of a 6K6.

As usual the power supply was badly designed, so the first action was to redesign it. It had no safety grounding and no fuses (when will radio amateurs learn about safety???), and when tested with a dummy load of 70 mA it gave 350!!! V out, the poor receiver is designed for around 220 V. The filtering was very bad, no choke or resistor, only a condenser of 16 uF. The transformer was fine and it fed a nice, classical 5Y3GT. The filament chain had been rewired for 6,3 V instead of the original 24 V and worked well.



Restoration

I will continue reporting on the restoration here on my site.

Report 1 March 12th: The power supply and the AVC-OFF-MVC switch

The first action was of course to fix the power supply. Safety ground and fuses were added and the filtering was improved by adding two power resistors and one more capacitor to form double RC chains. This also decreased the voltage to 220 V at about 50 mA. I will later add some dummy load to keep the voltage down until the filaments are warm, probably a zener diode arrangement. The blown capacitor was removed, I found out it had been designed for the 24 V dynamotor input but was now connected across the 220 V HT, no wonder it had blown!!

I made a quick listening check while monitoring HT voltage and current, the receiver worked! I heard some BC stations in the 49 m band in a short test. The anode current was a bit too high 70 - 80 mA, and I found it to be 40-50 mA even without the valves. I will now check all the components, probably I will have to replace some leaky capacitors.

A correct type of three way rotary switch for the AVC-OFF-MVC function was substituted for the DPDT switch repair, see photo. For safety reasons the mains was not routed over this as the 24 V was in the original, but a real mains switch, rotary, is inserted instead of the DIAL LIGHTS control.

The receiver is now very close to its original state and I will now check the components and then the function and alignment. The exploded capacitor has blown some wax over the interior so some cleaning is needed. When the receiver is working I will repaint the panel and the case with the right shade of wrinkle paint.

Report 2 March 14th: More on the power supply, resistance and voltage measurements

The power supply gives too high voltage, 350 V, during some 10 seconds until the filaments are hot. Will be cured with a zener diode chain of 4x56 V, 5W each diode, across the HT, this will load the output with 30 - 40 mA as long as the voltage tries to increase above 240 V, but will not draw any current when the valves are warm and the voltage is around 220 V.

[Final power supply schematic.](#)

The resistance between +HT and chassis was measured to be 4,6 kohm, a much too low value and responsible for the high current. By breaking up the anode chain in some strategic places I soon found that capacitor 11-6 had a short, grounding resistor 57-3/first IF. As the resistor is 4,7 kohm this was the cause of the low resistance between +HT and chassis. The capacitor was changed to a vintage Aerovox 0,05 uF 400 VDCW. The resistance to chassis was now 27 kohm which is quite reasonable. How the receiver could give any response with such a fault is a riddle, it should be quite dead really!

The HT current now was 45 mA at 215 - 225 V and the receiver was quite lively on all bands. Now I checked all the resistances and voltages at the valve pins and compared with the tables in the manual. Both measurements showed a couple of serious faults: The screen grid resistance and voltage on the mixer and also on the first IF was 0! The screen grid voltages on the first and second RF stages as well as on the second and third IF was only 50 V instead of more then 80 V. The fault was the decoupling capacitor of the mixer screen grid 11-5 which was shorted. I changed it to an Aerovox 0,05 uF 250 VDCW. The screen grid resistor on IF 3 was 480 kohm instead of 180 kohm, it was changed.

Report 3 March 15th: Change of output valve, resoldering of the heater chain

A batch of NOS spare valves were bought at Radio Daze in New York, www.radiodaze.com, and on eBay. They cost only \$4 as an average and a few dollars postage. The valve 6Y6G was changed to the original 6K6(GT) which takes only 0,3 A LT current compared to 1,4 A for 6Y6. The dynamotor fed a negativ grid voltage to the valve in the original circuit, this has to be substituted with a cathode voltage. As I do not need much power I decided to use the lowest voltages in the data sheet, 100 V anode and screen grid voltage and 10 V on the cathode, current 10 mA. I got this through a 10 kohm 2W resistor for the anode/screen grid and a 1 kohm resistor decoupled with 100 uF for the cathode. The entire receiver now took only 32 mA at 220 V!

The filament chain was badly soldered when changed from 24 to 6,3 V, I changed some wires and went over the solder joints.

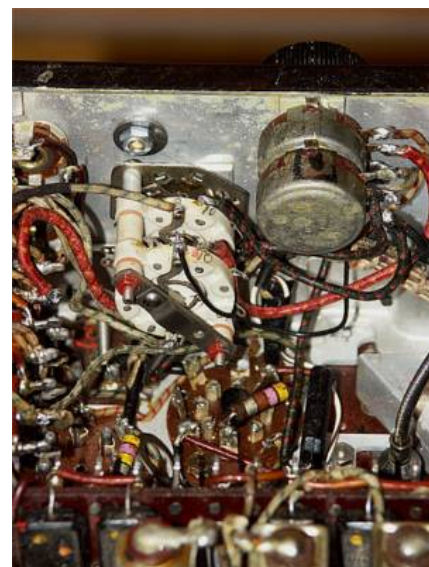
Listening tests gave a very good result on the 49 and 31 m bands. The AVC voltage varied from 0 to -10 V with the signal strength and the MVC was 33 to 0 V with the volume control, very good. The BFO and crystal filter worked fine. The receiver is now in place in the collection and I will make listening tests a week or two. The next steps will then be to plot the IF curve and measure and perhaps trim the sensitivity on all bands.

Report 4 April 4th: Testing and fine alignment of the IF

A 1 mV ptp signal from a signal generator tuned to the receiver intermediate frequency 915 kHz was connected to the mixer grid with a 100 nF capacitor. The signal was modulated to 30 % with 400 Hz. The frequency was varied and the output was measured at the headphone output.

First the frequency of the crystal filter was checked to be 915.00 kHz. All IF circuits were then aligned to that frequency, the output increased nearly 20%.

With the crystal filter OUT the bandwidth was measured to around 5.6 kHz (+- 2.8 kHz) @ - 3 dB and around 14 kHz (+- 7 kHz) @ - 20 dB. With the crystal filter IN the bandwidth was 400 Hz (+- 200 Hz) @ - 3 dB and 3 kHz (+- 1.5 kHz) @ - 20 dB (specified to +- 2 kHz).



With 1 mV ptp input the output was 12 V ptp, which is 1 mW in 20 kohm, the amplification in the mixer/IF/AF stages being around 12000.

Report 5 March 28th: Check and alignment of the frequency accuracy (the oscillator alignment)

A signal generator and counter was connected to the aerial input over a 100 pF capacitor as dummy antenna. The frequency was measured at the dial end points on all bands. All the four upper bands 3 – 6 are better then the specified tolerance (0.5 %). Band 1 has 1.4 % fault at 500 kHz, will be aligned, and band 2 is very inaccurate (up to 5 %!), will be examined and corrected later.



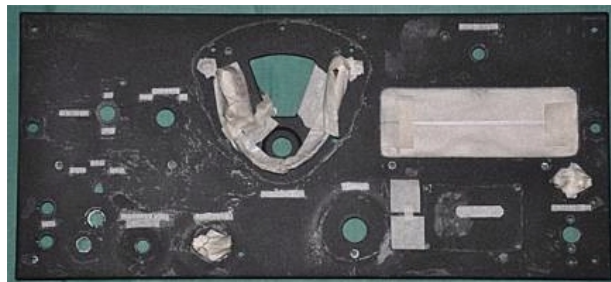
My BC-348-R in its collector environment! It remains to repair band 2 and to repaint the front panel.

Report 6 October 1st 2009: Repainting the front panel

The front panel was removed and the text masked with tape. The outer layer of paint was removed with a chemical paint remover, applied in very thin coats. The underlying wrinkle paint structure was thereby saved. Finally the panel was sprayed with two thin coats of mat black paint.

The plastic identification plate was original but in bad shape with paint and pieces missing. The paint on the back of the plastic sheet was retouched and the plastic sheet was then glued to a thin white aluminum plate. Missing pieces were replaced. The identification plate now looked fairly good and was riveted in place.

Two service stamps to the left of the plate were taped during the paint process and thus saved.



My restored BC-348-R receiver

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RECEIVER RCA BC-348 ACCESSORIES

Morse Key

My morse key type J44 is a J37 fixed to a bakelite base with a switch Teleg./Voice. The J37 key was the real "workhorse" during the war, it was used as the main part in different variants designated J43, J44, J45, J47 and J48. A very good overview of these models is given in link 1 below.

The key was of course wired to the transmitter BC349 or BC375, but it was sitting on the table in front of the radio operator with the receiver. I bought the key to resemble the operator environment.

The J44 key is 13 cm x 7 cm. The J37 is very nice to operate and still popular with radio amateurs.



Spare valves

The valves used in the BC-348-R are:
3 each 6K7 (first and second RF and first IF)
1 each 6C5 (oscillator)
1 each 6J7 (mixer)
1 each 6F7 (second IF and beat oscillator)
1 each 6B8 (third IF, detector, AVC)
1 each 6K6GT (AF stage)
1 each 991 (voltage regulator)

Most of the valves are metal types with octal base and top connector.

I have bought a set of spare valves, one of each type, from Radio Daze, link 2. The valves are NOS (new old stock), not used but of old manufacture and in original boxes.



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RECEIVER BC-348 PHOTO GALLERY

B17 Flying Fortress



The Experimental Aircraft Association's B-17G-VE, serial number 44-85740, nicknamed Aluminum Overcast, was delivered to U.S. Army Air Corps on May 18th 1945, just after the end of the war. It was restored in the nineties and is one of very few B17's still airworthy. It is used at air shows and is touring USA making passenger flights. The photos were taken by Claes Olsson NDL in Florida in November 2007.



The transmitter BC-349 which was used together with the BC-348 receiver for HF communication with the home bases. Here in the Aluminum Overcast.





This BC-348 receiver seems to have been in service.

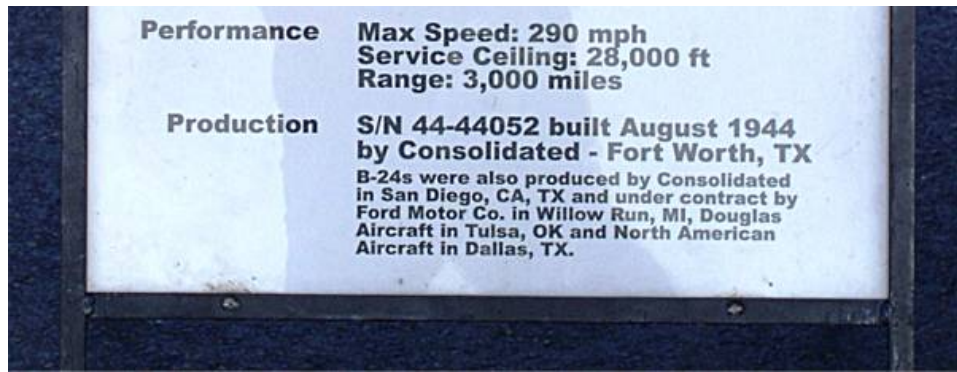
B24 Liberator



Collings Foundation's Liberator B24J "Witchcraft" was built in August 1944 by Consolidated at Fort Worth, Texas, serial nr 44-44052. It was restored in 1989 and is the only B24 still flying! It is used at air shows and is touring USA with passenger flights each summer. My sincere thanks to Tom Murphy for the photos taken in California 2008.

The B24 was faster than the B17 and had a longer range with the same bomb load. It was considered to be a little harder to maneuver and more vulnerable to enemy fire.

CONSOLIDATED B-24J LIBERATOR	
SERIAL NUMBER 44-44052 - "WITCHCRAFT"	
Wingspan	110 feet
Length	67 feet, 7 5/8 inches
Height	18 feet
Empty weight	36,500 pounds
Max. weight	65,000 pounds
Powerplants	Four 1200 hp Pratt & Whitney R-1830-65 Engines
Armament	10 .50 cal. Machine Guns
Crew	10
Performance	Max Speed: 290 mph



The receiver BC-348-N built by Wells Gardner seems to have been heavily used!

My BC-348-R

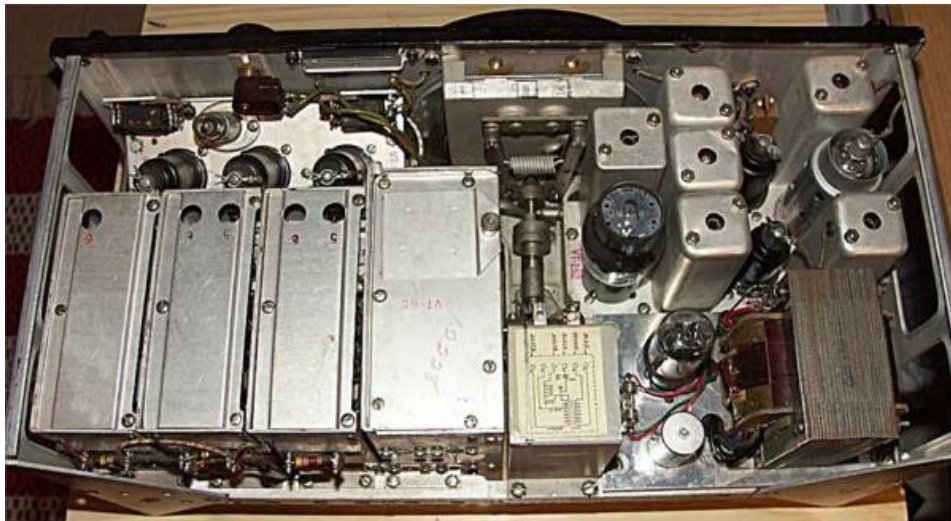




My restored BC-348-R in my little collection of receivers from WWII (before repainting the panel).

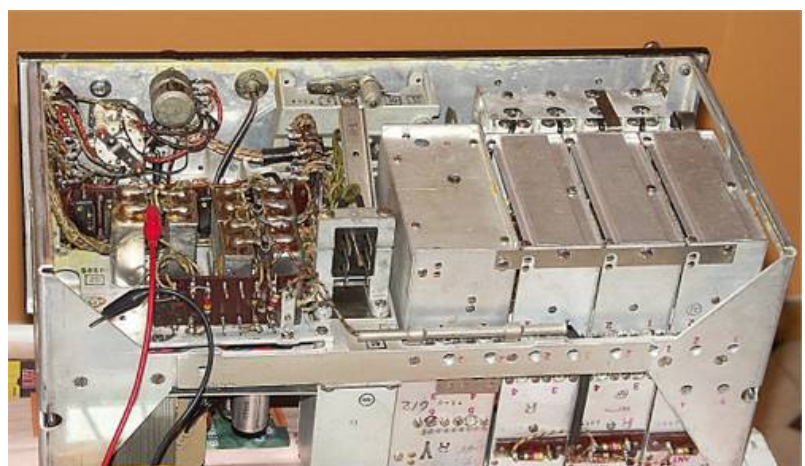


My BC-348-R with the J-44 key (before repainting the panel). The key is connected to a morse training oscillator.



The receiver is like new inside, except for the dynamotor.

The receiver seen from back/below. Most components are soldered to pertinax strips.





Last photos:
The receiver before repainting the panel. The service stamps to the left of the type plate are covered with paint and the type plate is tattered. The paint is applied in thick coats and with shining spots.



The completely restored receiver. The service stamps are now visible and the type sign mended. The receiver has the original mat black paint.

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