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The RCA 4-A-1 Condenser Microphone

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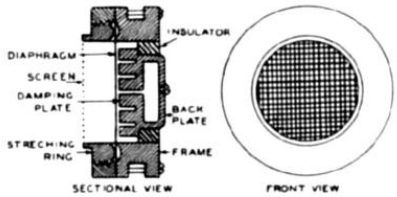
The RCA 4-A-1 condenser microphone was the mainstay of studio microphones starting in the 1930's in the NBC network. This microphone supplanted the noisy and low-fidelity carbon microphones, and the condenser microphone continues to be used to this day, because of its good fidelity and low internal noise.

CHRS has been fortunate to acquire one of these microphones. We have documented this microphone, as information about this microphone does not seem to be readily available, the microphone has been disassembled, photographed and an electrical schematic produced.

The back of the microphone that faces the audience shows the NBC logo over a USA map and an electrified microphone logo. The NBC logo is displayed diagonally on each side.

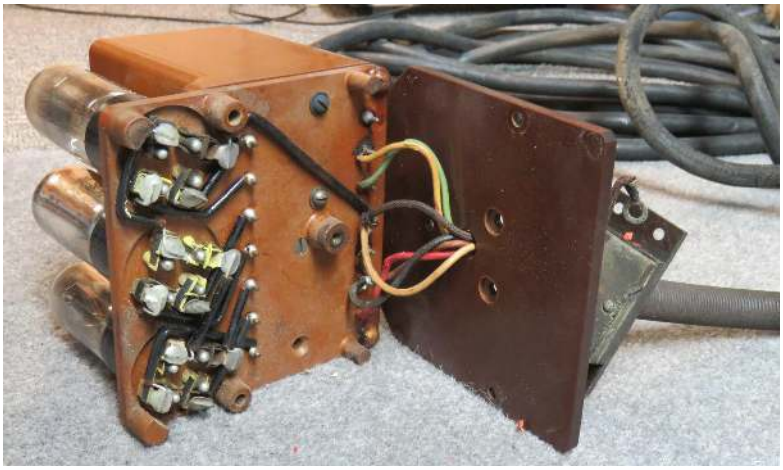
Inside the microphone body, a three-tube amplifier converts the very small voltage from the condenser element to a stronger signal on the output terminals. The amplifier is contained within a foam vibration and acoustic barrier, which has hardened in time but still fairly intact.

Looking inside the compartment, the back of the condenser element is seen. The condenser element consists of a backplate with a thin stretched diaphragm closely spaced in front of it that the sound wave causes to vibrate.



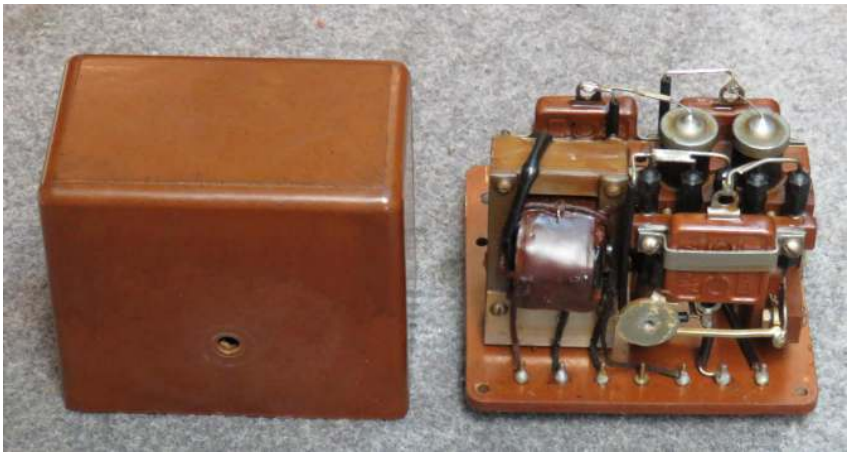
When the spacing between the diaphragm and backplate changes, a small alternating voltage appears on top of the large DC bias polarizing voltage between the diaphragm and the backplate. This small AC voltage amplitude is increased by the three-tube amplifier.

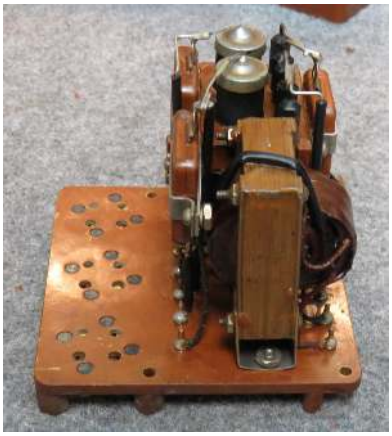
A 7-wire cable is attached to the bottom of the amplifier module. The color codes of the wires and attachment points to the amplifier module are mapped to the pins of the connector.

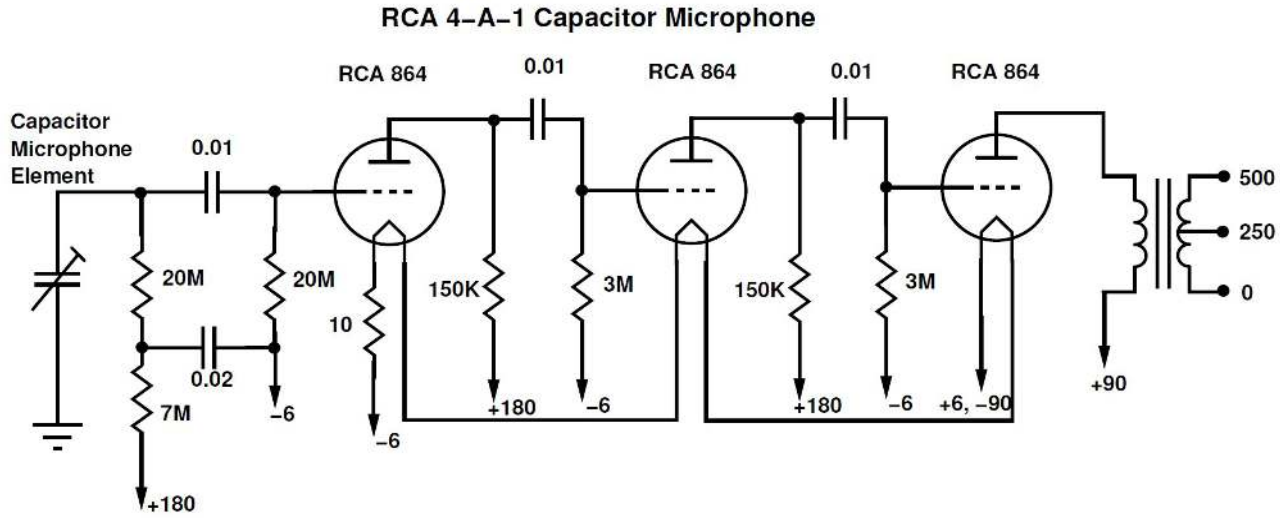


Inside the enclosing cap of the amplifier module are the passive components. There are four large mica capacitors, used as interstage coupling and power supply bypass, several large resistors in the Megohm range, and two large 150 Kohm resistors with metallic caps which are the plate resistors for the first two stages. An output transformer is in the plate circuit of the third amplifier stage that provides the audio output with taps for 250 and 500 ohm impedance. Only the 250 ohm output is brought out to the interface cable.

As received, the 150K plate load resistor in the second stage was open, and all the capacitors are leaky in the 100 Megohm range, with the 0.01 uF input coupling capacitor in the 1000 Megohm range. The unit may work with the present capacitors, but the open 150Kohm resistor must be replaced. All the tubes show good filament continuity and measure with a transconductance of 700 micromho with a Weston 686 industrial tube tester, but the pins need cleaning. The power supply must provide 6 volts at 0.25 A for the filaments, and 90 and 180 well-filtered DC voltage for the amplifier stages.







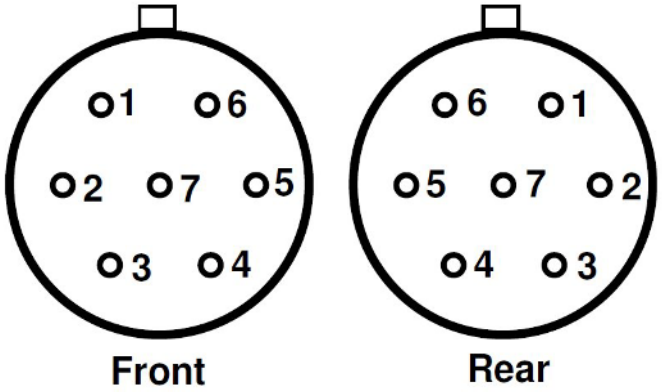
The schematic was drawn from tracing the conductors in the microphone itself. The resistance and capacitance values are indicated on the parts, and the operating voltages are etched onto the supporting structure.

The pin-outs on the connector were sounded out from the connector itself to their destination on the wiring board. The wires are color-coded.

The microphone with its power cord, as received is in moderate and somewhat dirty condition.

The long power cord is terminated at one end by the microphone with a spring sheath that reduces bending of the cable and at the other end of a large 7-pin connector.

The 7-pin connector pinout, according to the original RCA numbering scheme, is shown below.

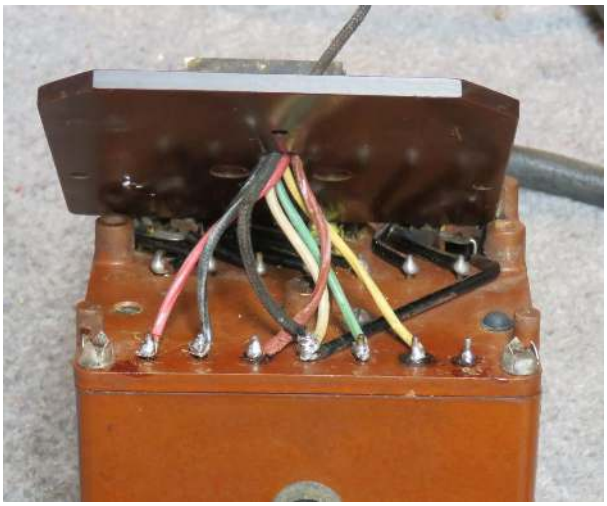


Where the functions are as follows:

Pin	Wire Color	Function
1	(none)	(none)
2	Black	-6 volt source
3	Brown	+90 volt source
4	Red	+180 volt source
5	Green	Audio output low
6	Yellow	250 ohm audio output high
7	White	Ground, +6 volt, -90, 180 volt return

The jacket of the first three feet of the power cord is in poor condition and the rubber-insulated wires exposed at the end are cracked.

The first three feet of the power cord is removed and the insulation stripped back to expose the six wires. The power cord is constructed for long service as under the rubber outer layer, a woven steel shield protects the enclosed wires. The rubber-covered wires exposed were in good condition and re-attached to the circuit board.



The condenser microphone cartridge condition was then assessed. Unfortunately, the condenser microphone was non-operational. Looking through the mesh grille, the diaphragm exhibited a mottled appearance.

After the grille was unscrewed to get a better look, the diaphragm appears to be covered with dirt. The dirt was carefully rinsed away with cotton swabs and water.

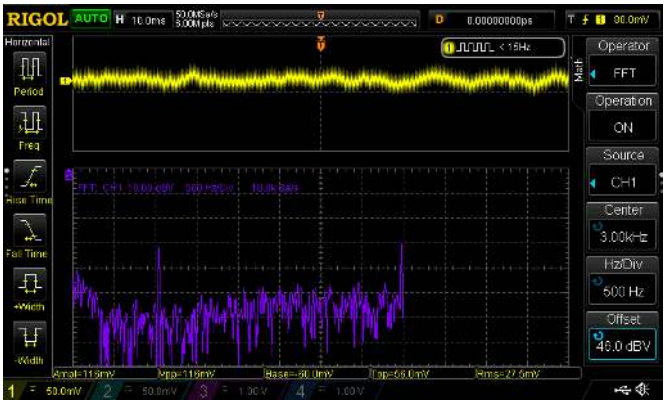
The diaphragm was found to be short-circuited to the back (ground) plane. The cleaning produced a temporary open-circuit, but the diaphragm would soon again short-circuit.

An attempt was made to remove the short by a controlled low-energy discharge from a charged capacitor across the terminals. This had the effect of partially removing the short, with resistance values sometime increasing to 100 Megohms with 50 volts across the terminals. The capacitance between the diaphragm and the backplate measured to be 130 pFarads.

The amplifier section was checked out with an external signal drive and found to be fully operational, once the open 150 Kohm resistor in the plate circuit of the second stage was replaced with a metal-film resistor. All other components were found to be good enough to be operational, in particular the input blocking capacitor from the microphone element to the grid of the first stage had a leakage resistance of 1000 Megohms. Operating the microphone at a reduced voltage of 40 volts on the first and second stage and 80 volts polarizing voltage on the condenser element and output stage would not result in upsetting the bias voltages on the tubes significantly.

An attempt to use the condenser element resulted in a low acoustical sensitivity with a large random noise background. The noise exhibits a “poor contact” noise characteristic and is dependent on the polarizing voltage.

The plot at the right shows a FFT of the output when whistling at about 1 kHz into the microphone. The peak is shown above a large noise background.



Voice recordings show that the voice is recognizable, but in a large pink noise-sounding background.

To determine the noise level of the amplifier, a condenser element of a modern MXL-brand microphone was substituted for the RCA cartridge.

The diameter of the MXL diaphragm is 20 mm: the RCA diaphragm diameter is 40 mm, so the MXL area is one-quarter of the RCA. If the spacing between the diaphragm and backplate is the same, the MXL would give roughly one-quarter the output for the same polarizing voltage.

The speaking tests showed a very clear and low-noise output with the MXL cartridge. No quantitative measurements were made of the signal-to-noise level, but the performance was quite satisfactory, showing that the amplifier in its current condition is capable of good performance. And this was made at an 80 volt polarizing voltage, below the default 180 volts for the RCA cartridge.

Although the microphone can be made to work with a substitute cartridge, it would no longer be an authentic RCA condenser microphone, so the decision was made not to substitute another cartridge but wait until the present one can be fixed or replaced by another RCA cartridge.

The microphone was reassembled with the stand interface which is threaded with a half-inch pipe thread microphone stand connector. The connector is detachable from the microphone with two acorn-shaped screws.

The microphone was given a simple cleaning, but not a cosmetic restoration.

If an authentic RCA cartridge element can be found and installed, the microphone will be again operational and operate as originally designed.

Recordings of other 4-A-1 microphones indicate that they are capable of excellent reproduction and served well for years in the broadcast industry.

Thanks to John Stuart for the loan of the MXL microphone.