The Astatic D-104 Microphone

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My first encounter with the Astatic D-104 microphone dates from the late 1940's, before I was licensed, when I became fascinated with ham radio. My 'elmer' would control his big, open rack, black wrinkle finished, rig with a chrome, wire mesh protected, (as if a caged beast was inside) D-104. When he pressed that push-to-talk bar, huge, oversized contactors and antenna transfer relays would energize with a loud KER-CHUNK causing meters, blue rectifiers, and red plates to came alive. Awesome. I wanted to do that! I suppose it was love at first sight, for ham radio as well as D-104s.

The D-104 and its unique configuration is pretty much a Ham thing. It was developed in the early 1930's by hams for hams and except for a little excursion into CB land has remained so to this day, a period of almost 70 years. It has changed little and is still popular and relatively inexpensive.

C. M. Chorpening, W8WR/W8MMJ, and F. H. Woodworth, W8AHW, both avid AM'ers looked for an improvement to the carbon mics of 1930, and built a few condenser microphones, (Hmmmm, are they called capacitor mics today?), before producing the crystal mic out of Rochelle Salts, (Sodium Potassium Tartrate). They incorporated in 1933 and went on to produce crystal; microphones, phonograph pickups and recording heads. Their legacy is still doing business as the Astatic Corporation.

The familiar D-104 'Chrome Lollypop' graces many shack pictures and old advertisements of other ham gear. This mic together with the hand key profile is almost a trademark of ham radio, and the mic is certainly a good candidate for a symbol to represent AM phone operations.

The Astatic D-104 microphone remains one of my favorite and is the microphone of choice for many AM/ Boatanchor operators. Besides being a good performer, it has a significant mystique associated with its looks. It projects a very manly image and feels solid of heft and fits in the hand, as a fine target pistol would, unlike those wimpy little flexible shaft Q-Tip things or liver colored transceiver squeeze mics that make you look like you are covering a sneeze. I won't comment on those ice cream cone karioke things, but Elvis wouldn't have used one. The old military T-17 carbon mic is a close second favorite for form, but that is another story.

Today's Hams Want Better Audio

Today AM'ers, and SSB operators as well, seem to be on a quest for better sounding audio. It has almost become a sub branch of the hobby. Everyone has their opinion about the best mic, equalizer, processing, etc. and often there are conflicting views. I also have a fairly large pile of 'Stuff Tried'. During this experimentation I was using my old faithful D-104 as a standard of quality for comparison with the configuration of the day. I reasoned, this is silly, using this $35, swap meet, mic as the type of on air sound I like, why not put some effort into finding how to make its performance better?

The remainder of this article covers three main topics;

From the late '40's until the present time the D-104 has been the most popular microphone amongst hams.

*My findings and observations on getting the most performance out of the D-104.

*A description of a simple modification to extend bass response that almost provides an "Equalizer in the mic base".
*The final section is composed of reference notes and repair information.

The D-104 Sound

The key to the D-104 sound is clearly seen by observing the response curve of Figure. 1. The rising characteristics from about 500 Hz with a big peak at 3 kHz and rapid decrease thereafter. The response at the low end, as discussed below, depends on the crystal element load impedance.

Good Bass Response Requires High Load Impedance

Through the years many have experienced poor results when trying to use the D-104 to drive low impedance inputs, in particular transceiver inputs which are around 600 ohm impedance. This lack of performance for this task is common knowledge. In fact Astatic's amplified mic base was developed to address that need in the CB market. Numerous circuits have been published for active impedance transformation using MFETs etc. Many of them use a 100 K ohm resistor in the input. This leads one to believe 100 K ohms is a good value to use, and indeed it is, if you are not concerned about lows below about 500 Hz . The Astatic stock amplified CB mic has a measured cut off of about 300 Hz .

A search of literature regarding the proper load impedance for the crystal cartridge is summarized by the following:

A quote from, W. F. Soules, W8HCW, Electro-Voice Inc., (QST, January, 1958, pg. 30); "With a crystal microphone, the bass response is governed by the value of the grid resistor in the first stage. An input resistor of 100K will limit or "rolloff" at about 500 cycles, 500K at about 250 cycles, and a 1 megohm will extend the response to about 100 cycles.".

Interestingly, here is a comparison of typical catalog specifications but with the lapse of 41 intervening years.

Harvey Radio, 1959; Imp = 1 to 5 meg ohms Response = 30-7,000 cps rising 500-4,000 cps

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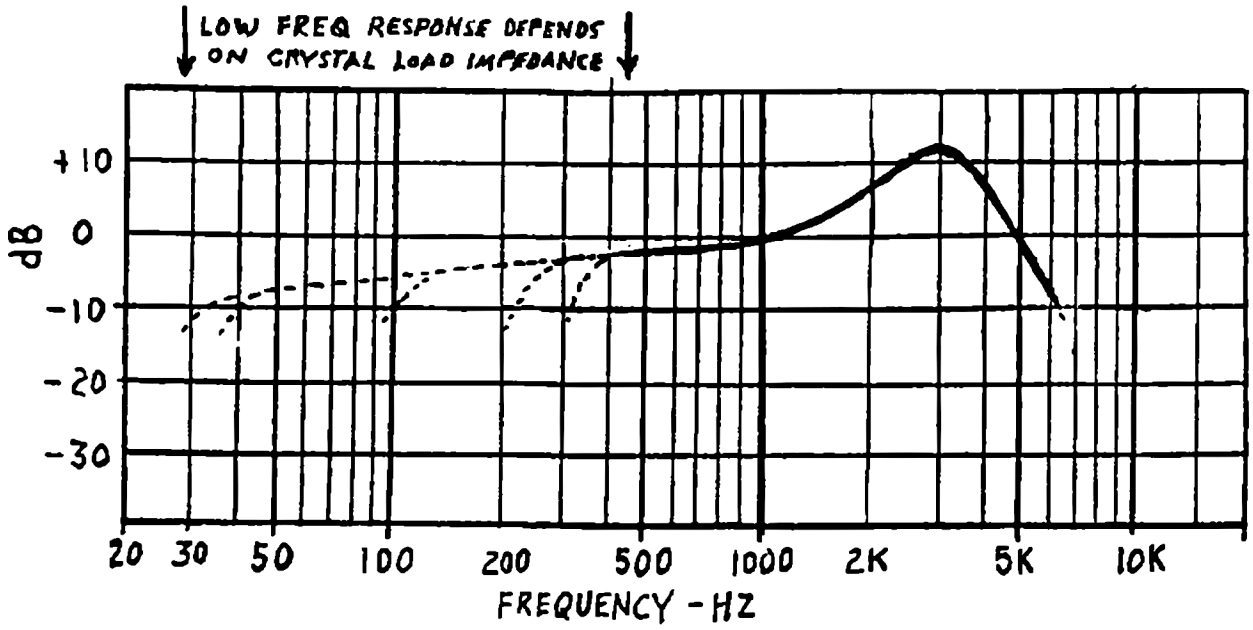

Figure 1. D-104 crystal element audio response. Showing typical shape and how low end is affected by load resistances between 4 meg ohms and 100 k ohms.

Amateur Electronic Supply, Summer, 2000; Imp = High Z Response = 300-7500 Hz rising 500-4,000 Hz

I conducted my own rough experiments using an audio signal generator into a quality response headset taped to the D-104 head and observing the output. (An amplifier with 6 meg ohm input was used to amplify the element output.) With the limitations of setup well in mind, it confirmed the response curve was as above except my highs were almost gone above 5 kHz. In addition the low end response was very much a function of crystal cartridge shunt resistance value. It is a surprisingly striking and significant effect. However the mid and high frequency response was minimally affected for load variations above about 50 k ohms.

There have been a few who knew the truth all along. Tim "Tim Tron" Smith, WA1HLR, east coast AM guru, has for years preached the virtue of using bare D-104 crystal elements into mic input amps in Boatanchors with 5 Meg ohm or greater grid input resistors.

Practical Implementation of a High Input Impedance

Five Meg ohm inputs do indeed produce great sounding audio with plenty of lows and a nice AM signal. I routinely incorporated that in my transmitter audio circuits. I also found that this as well as extending the modulator chain to include lower frequency response, greatly increased my hum problems. Design, wiring and layout problems appear that the old Boatanchors avoided by limiting low end response to about 300 Hz. These hum problems sometimes require an inordinate amount of work to resolve. In addition, with that high an input impedance, the 60 Hz environment in my basement shack is high enough to cause a problem with just 4 feet of shielded mic cable on the floor. The simple, straight forward, solution is to put the high impedance load together with a pre amp right inside the shielded mic element enclosure and bring out the signal at more forgiving low impedance, an old but graceful remedy.

The idea dawned to install a 3.3 meg ohm resistor in series between mic element and the stock D-104 preamp. The amp will compensate for loss of gain and produce a low impedance output. The high impedance load on the crystal element will enable response to 30 Hz on the low end with minimal effect on mid or high end audio. Now, if

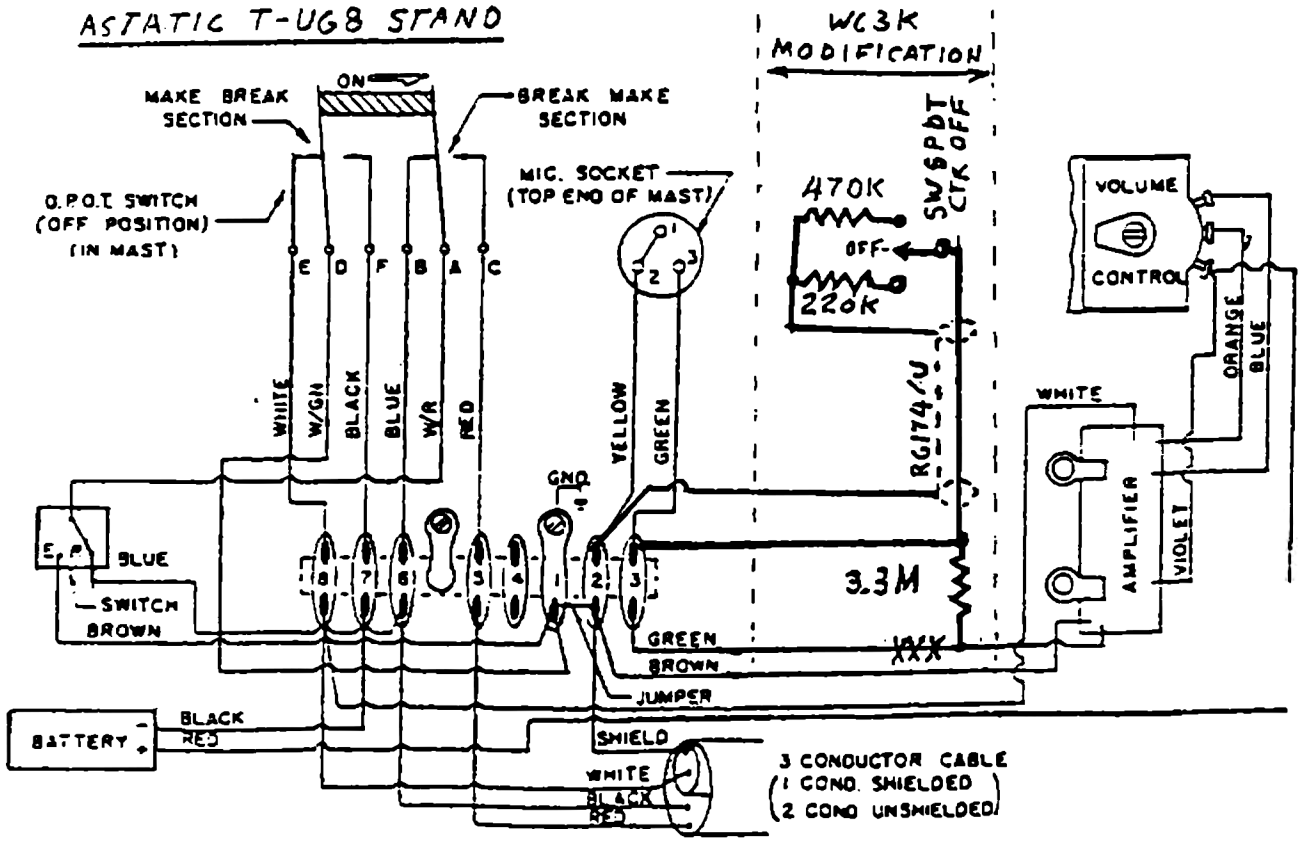

Figure 2. Schematic of Astatic T-UG8 mic stand with the simple WC3K modification to allow selection of three bass responses.

an additional resistor is placed to shunt the crystal element, the low end response becomes a function of the shunt resistor's value. (higher resistance, more lows.) This allows one to conveniently set low frequency response by changing the value of one resistance element; a convenient equalizer in the base of the D-104.

The WC3K D-104 Bass Response Modification Details

This modification is very simple and allows a clear demonstration of the effects of crystal cartridge load impedance on the low frequency response. I have modified several, each with slight differences, and have arrived at this configuration as the most usable. It costs about $5 for parts that are available at your local Radio Shack.

Obtain a D-104 with a T-UG stand, the 'T' means it has a transistor preamp, the 'G' means it has a 'grip' push-to-talk (PTT). (If you are shopping for one at the hamfest, it has the adjustment slot of the nylon gain pot visible through the 1/2 inch hole in the bottom plate.) You can put a superior JFET preamp (See ER, Dec. 2000, pg 35, for W6VMI's circuit for a good start.) and a 9 volt battery in the non amplified model, G or UG, with a little more work. In any case the preamp is needed to act as a high to low impedance transformation device and to provide some gain.

The modification adds 3.3 meg ohms (three, Radio Shack, 10 meg ohm, 1/4 watt, resistors in parallel) in series between the crystal cartridge and the pre amp. This is physically done by removing the bottom plate of the D-104 stand (3 screws). Viewing the bottom with the mic cord in the down position, a green wire will be seen connected between the right-most terminal (#3) of the 8 terminal strip and the lower right corner of the preamp circuit board. Open this connection and solder the resistors in its place. With this simple action, the crystal cartridge will now

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provide almost all its bass capability. The total load impedance including the stock preamp input impedance is almost 4 megohms. I have experimented with higher series resistance (5 and 10 meg ohms) but that leaves the total mic gain through the preamp a little lacking and does not significantly increase the response to be a good trade-off. Stop here if you are using an equalizer such as the W2IHY 8 Band Equalizer, (Highest input impedance is about 25 K ohms). Now there will be plenty of bass available for the equalizer to work with and you can shape it the way you want. If you tried to use a bare D-104 before you will be surprised at the increase in the low end.

If you plan to use the modified D-104 directly into a Valiant, DX-60, etc. or even a transceiver, there may be conditions when this mod provides too much bass. The further modification as shown by the schematic of Figure 2 allows three choices. The single pole, two position/center off, mini toggle switch selects either no shunt or one of two values of shunting resistance (470K and 220K ohms, 1/4 watt). I chose these by experiment to suit the sound I liked at 6 kHz and 4 kHz monitor receiver IF bandwidths respectively. The switch mounts neatly and out of the way on the lip of the mic base about 3/4 inch to the right of the cable exit hole. Use a piece of shielded wire or RG 174U mini coax to bring the connection to the switch. Resistors mount by their leads to the switch and shield. You might want to experiment with other resistor values. I made one configuration using a mini 1 meg ohm pot and switch. The infinite range of values and choices resulted in personal frustration and I didn't consider it convenient. Though one may enjoy driving your buddies crazy playing the ' Now how's this sound? - Now how's this sound?— — — Now how's this sound? ' game. He, He, He. About as much fun as I have during Sweepstakes Contest and with the equivalent intellectual content.

Reversible Audio Phase Modification

If you are techno-compulsive like me, it is desirable to have the non symmetrical speech wave form of your voice phased so the higher peaks produce modulation in the positive direction at the AM transmitter output RF. This is easily done by reversing the leads on the mic element so the phase is correct. I modified one mic to include a DPDT mini switch in the mic base to do this function. The grounded side of the crystal cartridge is ungrounded at the head and brought to the base switch via an extra wire threaded through the shaft. If you are really into external processing you probably have other devices that will better provide this capability.

Sundry D-104 Information

The following are observations and sundry bits of information from my D-104 notes that may prove useful.

The D-104 Microphone has remained pretty much the way it originally was, however the ceramic cartridge was added as an option to the basic crystal cartridge, as a more environmentally robust element. There have also been improvements to the enclosure techniques/materials for the crystal itself. As previously stated I prefer the crystal for the way you can shape its bass response. The elements are housed in the 'head' that can be plugged onto a number of base support configurations. The most commonly available stands have a bar on the stem that when depressed/gripped activate a push to talk switch closure and also ungrounds the element output. These stands are the G and UG (G = Grip) which delivers the bare element output to the connector and requires a high impedance load; and the T-UG (T = Transistor) which includes a little two transistor pre amp and 9 volt battery in the base and provides an amplified signal that will op-

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and sometimes still longer than the readily available Radio Shack #278-356, $3, curly cord replacement. Proper wire for mic cables has a separately shielded wire for the mic audio and one or two other conductors for the push to talk relay circuit. It should be soft and pliable yet durable to withstand the handling it will receive. It is becoming increasingly difficult to find.

D-104 PTT Switch Adjustments

The mic stand shaft must be disassembled to gain access to the PTT switch:

* First remove the mic head, then remove the PTT clip off the top of the shaft.

* Remove the one screw at the top of the mast that holds the mic head connector.

* Remove the two screws at the base of the shaft that hold the PTT lever bar and remove the bar.

* Remove the two screws midway up the shaft that were under the lever bar. These free the PTT switch inside the shaft.

* Remove the last screw at the base of the shaft. Lift the shaft barrel straight up to free the PTT switch and mic head plug. These will be held suspended by the wiring. When making repairs try to minimize disturbing this alignment.

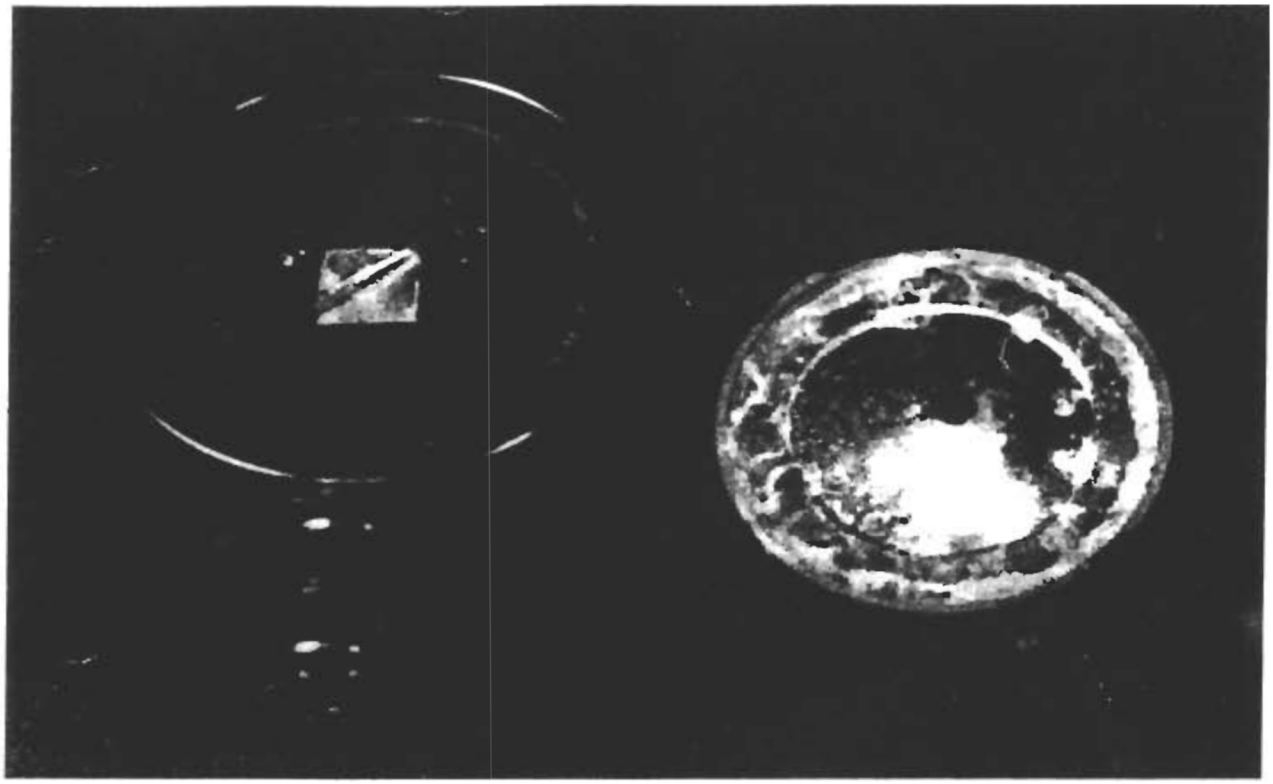
Reassemble in reverse order. The only tricky part is realignment of the PTT switch and mic plug screw holes. A round toothpick used through the screw holes helps reposition everything.

Once exposed, the action of the leaf spring contacts is easily understood, and access to the contacts is good. Sometimes a simple cleaning is all that is required. First give the contacts a light burnishing with a dry strip of note paper pulled through each set of contacts while holding the contacts closed. Usually the black crud quits leaving a mark on the paper after about three passes. Repeat the operation with a new paper strip which has been freshly dampened with Deoxit contact cleaner.

Sometimes the leaf springs require physical adjustment as the spring relaxes with use. While it can be done with small needle nose pliers a special tool will make it much easier. I use a soldering tool that works as well as the old Western Electric tool I misplaced years ago. One end has a 1/8 inch round steel rod on which the tip has been split for about 1/2 inch so that it looks like a tiny tuning fork. The two prongs are 1/16 inch apart. One could be made by splitting a large nail with a thin hack saw or Dremel wheel. The tool is used by placing the prongs around a switch leaf and applying rotation force to the tool to move and reset the spring's position as needed. Control is quite good once you get the hang of it. From the schematic, note that one contact set is make-before-break and the other is break-before-make.

Repairing Crystal Cartridges

There is a lot of advice about the need to replace the crystal cartridge because of its fragility, sensitivity to environment, and aging effects. I am sure when compared to ceramic that is true, however my experience with over two dozen, swap meet specials of various age and condition (including one with a fire discolored base) has been that the crystal itself is usually very usable, some have a little more or less output. This is not a problem if you have the kind with the preamplifier in the base. (There are Hams that recommend scrapping the little pre amp, but I suspect they are just suffering from "CB Envy".) All but four are working after repairs including the 'Unkie Bill Cure' that follows. Note that there is an advantage to trying to save and use the older crystal cartridges. (The oldest mics have little aluminum trade marks rather than decals.) I think they seem to have a little more low end response than today's fresh from the box elements, but that observation may



The photos of the inside of an old D-104 head show the elegant simplicity of the crystal cartridge. The square in the middle is the Rochelle salt crystal block with sandwiched electrodes. It is supported by spots of adhesives on the mounting disk at two diagonal corners. The remaining diagonal corners are attached to a metal "inverted T stirrup" with a post at the center for attachment to the center of the acoustic diaphram. The "wax like" adhesive can be seen around the small hole at the center of the thin aluminum diaphram.

be just my perception and preference for old things. (Like my hat, truck and XYL.) However the published specs have changed a little over the years.

Unkie Bill's Cure

If the mic output is hooked to the most sensitive setting of your scope or audio amp and shouting into it produces a detectable output no matter how limited the audio response, it is probably fixable. If it is dead-dead-dead after inspection of the remaining circuit path, the crystal is probably defunct.

Remove the mic head by unscrewing the large knurled nut and unplugging from the stand. Remove the four screws holding the front (screen) side to the back side, and carefully remove the front. There is a black fabric circle backed by a 'fiberglass looking' blanket that may stick to the element, just carefully remove it. This gives access to a large but fragile aluminum diaphragm that is attached to a small metal stake at the center. This stake couples the acoustic vibrations from the diaphragm to the crystal. The coupling adhesive is a small bead of wax material. Close inspection with a magnifier will sometimes reveal that the wax is broken loose at the stake and is the problem. Mechanical and/or thermal conditions are a likely cause.

This wax can be rebonded by carefully melting with a pencil type soldering iron. A 15 watt Radio Shack iron works. Place the iron in contact with the tip end of the 'metal stake' for a short second and remove it. You want it hot enough to just liquefy the wax at the break point. I now use a home light dimmer to control the iron temperature. Start cool and move up in temperature. If you over melt and lose or vaporize the wax., use a match head size pellet of bees wax, or if you have a friend that

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If you already have plenty of D-104s in the shack, consider a Heil cartridge available for about the same price, or the excellent response, Radio Shack #270-092C, $2, condenser element, it needs a voltage source but is straightforward to implement. In either case you will retain the classic looks of the D-104 with little additional expense.

Refinishing The Painted Base

Damaged paint on the base is common and can be fixed by repainting, however my favorite method is to remove all the paint with sandpaper then polish the base pot metal with successive grades of auto rubbing compound until a high gloss, mirror finish silver look is achieved. It must be covered with brass lacquer or it requires a polishing every few months. Looks grand.

Conclusion

The D-104, at almost 70 years old, is still going strong. When operated into a proper high impedance it is still hard to beat for the audio quality that most AM'ers like. Performance, repairability, and economy, all packaged in a compact form that enhances the look of the AM Boatanchor shack. Used correctly it will remain the mic of preference for many of us. You and your listeners will like it even better with the described modifications. ER

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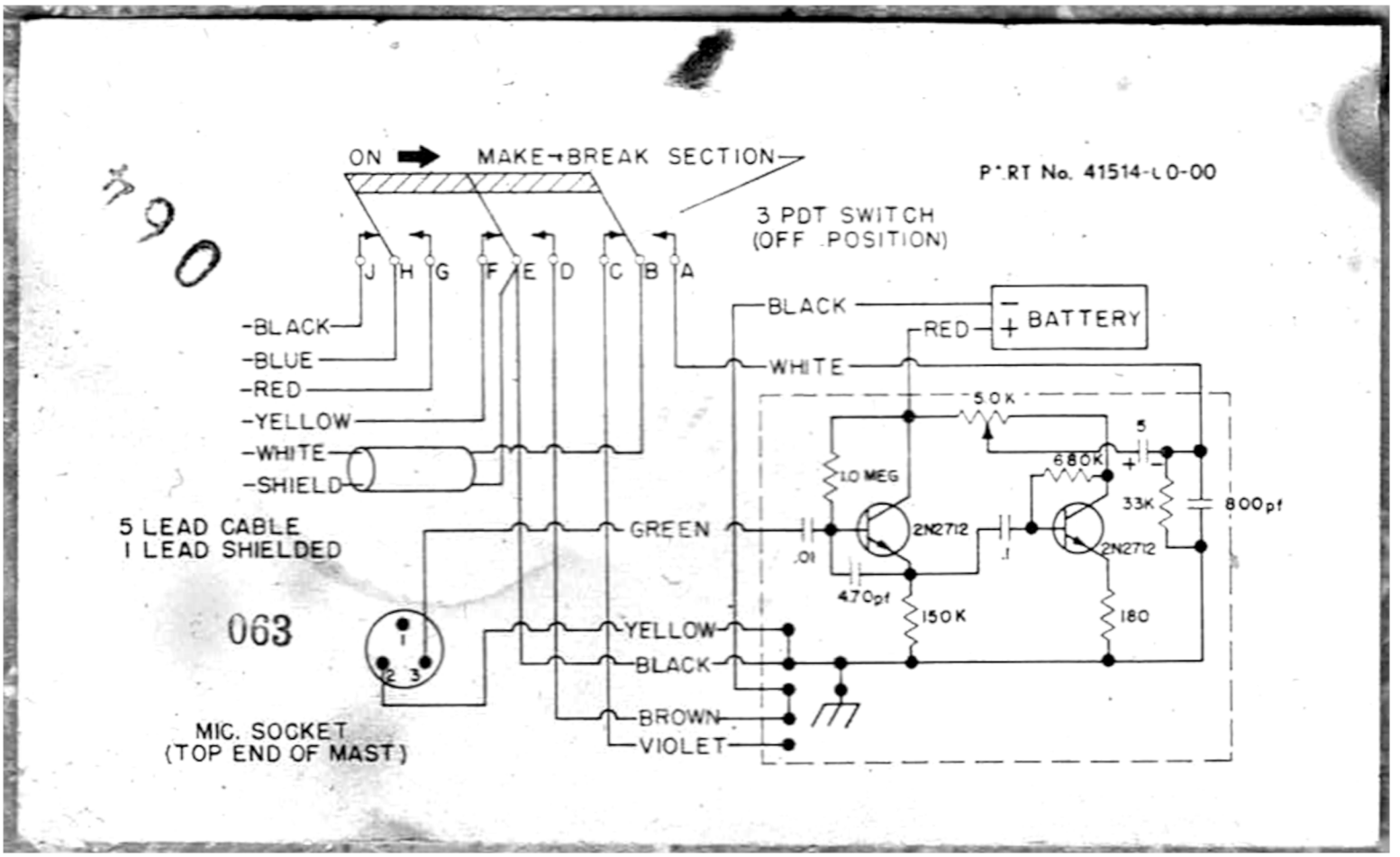
does lost wax casting get a bit of harder model wax. Works nifty keen. A very satisfying repair that prompts me to cry out: "It's Alive, It's Alive!", in the fashion of Dr. Frankenstein.

I have repaired large dings in the fragile aluminum diaphragm, however if it is reworked very much the low frequency audio response suffers. You do it like audio body repair, poke a small hole and pull the big dings out with a tool you make from a paper clip. Small holes are not detectable by my ear.

If the above measures don't work, it is a relatively simple task to replace the entire cartridge with a new one, either ceramic or crystal. They are available from a number of dealers for around $30. The cartridge has two solder lugs in back on which to tack the two wires.


ON
MAKE-BREAK SECTION
PART No. 41514-L0-00
3 PDT SWITCH
(OFF POSITION)
J H G F E D C B A
-BLACK
-BLUE
-RED
-YELLOW
-WHITE
-SHIELD
5 LEAD CABLE
1 LEAD SHIELDED
BLACK
RED
WHITE
GREEN
YELLOW
BLACK
BROWN
VIOLET
BATTERY
5.0K
10 MEG
6.8K
5
33K
800pf
2N2712
2N2712
.01
.1
470pf
150K
180
MIC. SOCKET
(TOP END OF MAST)