THE AMAZING ZC1 MKII.

A NEW ZEALAND MADE MILITARY COMMUNICATIONS RADIO.

Hugo Holden. Feb 2024.

ZC1 History:

In the early phases of WWII, the New Zealand Government decided that their troops required a better standard of field communications radio than what they had. They wanted a transceiver that suited NZ conditions and those of the Tropics, characterized by bushland and jungles.

The design and build task was due to Collier and Beale of Wellington NZ. They designed the first model, the ZC1 MKI. By April 1942, they had amassed enough resources to build 750 units of the original MKI design. By December 1942, the first production batch was shipped. There were a few small variations of the MKI model, not discussed here, as this article is primarily about the MKII. The subsequent re-designed model, the MKII, was created by R.J. Orbell of Radio Limited (Radio Corporation of NZ).

At least 5000 units of the MKI were manufactured and in the order of 10,000 units of the MKII, though estimates vary. I have seen one estimate that 30,000 total units may have been made, but possibly that figure was a target. The exact numbers may never be known. As usual the serial numbers were somewhat non-specific and not helpful due to secrecy issues.

The entire ZC1 Radio project was not a cheap undertaking for the NZ Government. Accounting for both models and total numbers, in the order of 14,000 to 15,000 units, cost 3 Million NZ Pounds in the 1940's era.

At that point in history the NZ pound was valued at 0.8 of the Australian Pound. The total cost was equivalent to about 2.66 Million AU pounds at the time. Translated on the RBA's pre-decimal inflation calculator, this is a staggering $234 million of today's Australian dollars.

If the estimates of the ZC1 units are correct at around 15,000 and the cost in today's dollars about right, this is in the order of $15,600 AU dollars per ZC1 set, in today's currency. (I have seen an estimate that each ZC1 set in NZ currency cost $40,000 to manufacture, corrected to the year 2009, but I am not sure how that figure was calculated and it appears too high). Still, the ZC1 was a very expensive radio.

56 factories were involved in the production of parts and sub-assemblies and some 900 people. It took about 60 Man hours to build one set and about 20 sets per week could be made, initially at least. However production must have sped up as time passed to five times this or more, to complete the near 15,000 units by the end of WWII. I have not been able to determine if any production of new sets went on to any significance past 1945 or not. It is quite possible some new ZC1's were being manufactured specifically to support the NZ & British occupation forces in Japan (J-Force) in the 1945 to 1948 period.

The ZC1's saw service in the Pacific War Campaign and large numbers of them were sold to the Middle East, however this was too late for them to see any significant service.

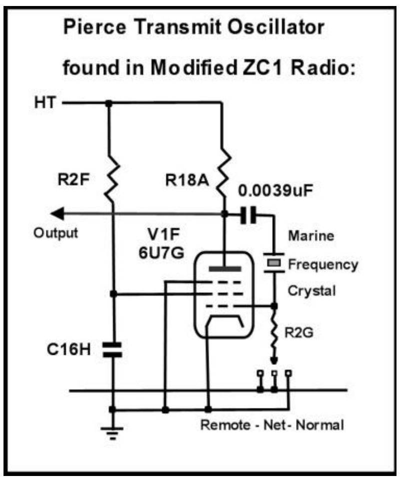
After the War, ZC1's were deployed by NZ Government agencies for various mobile and fixed station applications, right up until the 1960's. At this point they started turning up in Army Surplus stores in good numbers, many being cannibalised for components. They were typically used by Radio Hams on the 40 & 80 Meter bands (7.5MHz and 3.75 MHz respectively).

There was a ZC1 radio installed in the Radio Room of the Grammar School that I attended in Auckland in the 1970's. I cannot recall if it was the MKI or MKII model. By then I had already seen many of the components which had been removed from these sets and seen the ZC1 radios and parts in Army Surplus stores too. In the early 1970's, my brother had used one of the open frame relays taken from a ZC1, in conjunction with a capacitor, to build a 230V light bulb flasher.

The components in the ZC1, knobs, potentiometers, switches, dials, tubes and tube sockets, coils and shielding cans, variable capacitors, resistors and fixed capacitors were all of outstanding quality. These items made for an extremely attractive and economic source of parts for many projects. These were especially good for young people, interested in learning radio and electronics and short on their cash. The solid black phenolic knobs and other parts, even today, 80 years later, look just as good as new.

In other post War applications, the ZC1 radio found their way into fishing boats and other Marine applications. Many were modified to be Marine band radios. One of the ZCI MKII radios I have, had its transmit VFO replaced by a Pierce crystal oscillator circuit running a 2128 KHz Marine frequency. I converted it back to original.

Collier and Beale supplied a conversion kit for Marine use in the post War era. This is the modification I found in one radio, it may well be the modification recommended by Collier & Beale:



Many ZC1 radios acquired all kinds of modifications. Unmodified ones became very hard to find. These days, due to the historical significance of these radios, most owners want them to be put back into original condition.

As seen in the photo, one of the attractive features of the radio’s front panel is a pocket Watch holder. One challenge is to find a suitable period correct military grade pocket watch to fit in that holder:

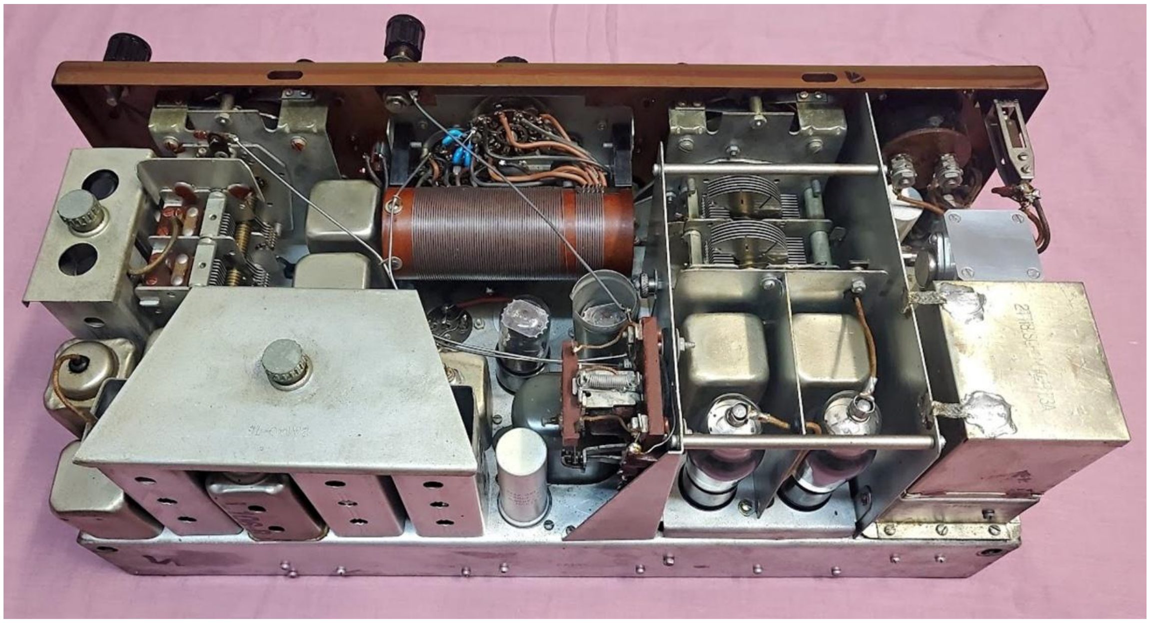
Also of note, the Red and Blue rods on the main receive and transmit tuning knobs: These are called “Flick Set Screws”. These allow mechanical storage, if you like, of two frequencies, so that the tuning knob will return (flick) to the exact position and frequency where the screws were tightened, if they were previously set and the Flick knob is deployed.

ZC1 - General Design and Specifications:

The radio is a very solid affair, being built into a steel enclosure, the inside of which is heavily Copper plated and with a tight cover that seals it, with a rubber seal. If the unit was dropped in water, with the front cover on, no harm would come to it.

The ZC1’s front cover:

The main assembly is ejected from the housing by two large front panel screws and slides out for easy servicing.

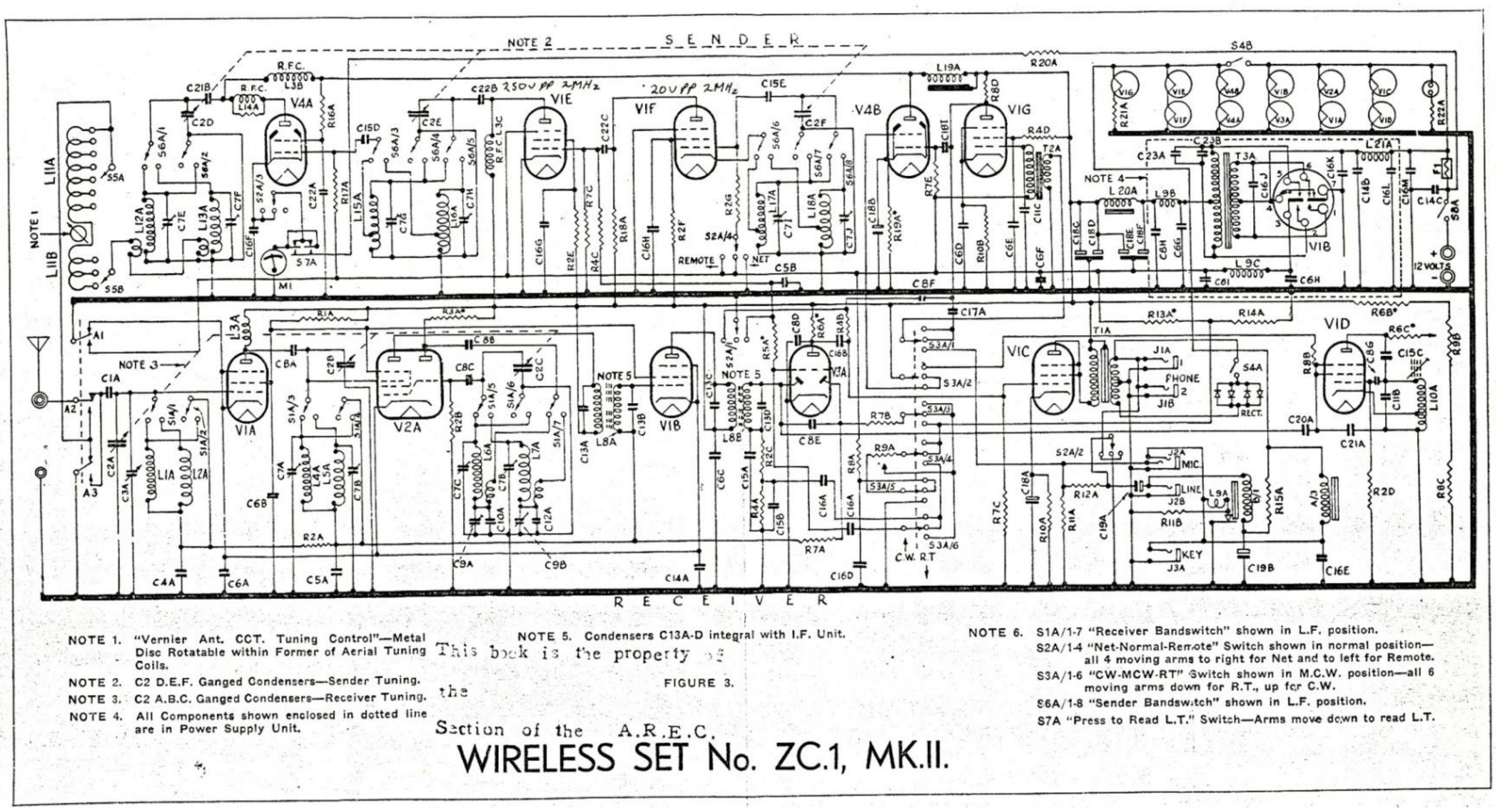


The Vibrator transformer (seen lower right on a sub-chassis) was well encased in a shielded container and all measures were taken to prevent RFI leaking out of the vibrator power unit and creating radio interference. There is only a very small amount of background interference with the original V6295 mechanical synchronous vibrator. When using an electronic vibrator replacement, no interference of any significance occurs.

The electronic components in the ZC1 were heavily “Tropicalised” with wax impregnation. Even the usual wax-paper capacitors in the unit were “double sealed” inside additional metal housings with a waxy oil, to prevent moisture ingress. All of the other transformers were impregnated and sealed in metal containers as well. Even the hook-up wire was said to have been treated with a “non vegetable Lacquer”. This was all in aid of reliability in moist bush or jungle environments.

One of the main features of the ZC1 (unlike a lot of modern equipment) it was specifically designed for easy servicing. And it was very well documented, not just with a comprehensive working instruction manual for the operator, but also a schematic and parts list which provides an extraordinary level of detail.

The ZC1 MKII Schematic:



Many of the capacitors, including the Mica types used in this radio were made in New Zealand with Mica from NZ's Mica Mines. There was a shortage of components at the time in the early WWII years, especially capacitors. Many of the wax paper capacitors were also made in NZ, though some were imported (see notes on the "Dwarf Tiger" capacitor found inside the metal housing of one capacitor below)

One thing that characterized the ZC1's of both MKI and MKII models, is the ability to transmit and receive on two different frequencies.

The radio is powered by a 12V storage battery, typically two 6V units in series for the ground stations, or the 12V battery in the Jeep or Truck for mobile use.

Although the unit was said to be "portable" it weighed some 27kg, somebody had to carry the batteries too. Many units for this reason were fitted into Jeeps & trucks. Two people could carry the ZC1 easily as it had a handles on each side of the cabinet. A one person carry, for more than 50 to 100m walking would be a tall order unless they were very fit.

For the MKII radio, the current consumption is quoted at 2.8A in Receive mode, Sender OFF and 3.8 amps with the Sender ON. In send RT mode it is 4.9A. Close to 2 Amps of that of this total is for the tube's heater currents. The 6.3V heater tubes are strung in series pairs across the 12V power supply and since there are 11 tubes in the radio, one tube required a heater ballast resistor in series. The battery life, using an 80Ah battery setup, is in the vicinity of 20 Hours with the transmitter used a quarter of the total time.

The RF output power is in the order of 2 Watts for the ZC1 MKII. Although I have found with a near perfect impedance match into a 50 Ohm load with a Balun and slightly modified coupling, it was able to achieve 3W output on 80m and easily 2W on 40m.

The transmission modes are CW (carrier wave), RT (carrier wave amplitude modulated by the microphone and MCW (Morse code Telegraphy, where the carrier wave is transmitted with an audio modulation tone applied).

The source of this modulation tone for the MCW mode is acquired by switching, to create a positive feedback pathway and make the microphone amplifier stage V1G oscillate. This was easily achieved because the microphone, being a dynamic type, required a microphone matching transformer to drive the grid of the 6U7G microphone pre-amp tube. This tube drives the 6V6 modulator tube V4B. An appropriate feedback capacitor switched in, the pre-amp stage, tube V1G, is made to oscillate at 800Hz.

Another feature was, the 800Hz oscillator was enabled in both CW and MCW mode (even though in CW mode, the modulator was disabled). The oscillator output was cleverly coupled through to the audio stage and headphones, so that the operator could hear a "sidetone", or beep, when the Morse Key was deployed. Also, in RT mode, the sidetone, to call it that, was instead the actual spoken voice into the microphone, helping the operator to "hear himself talking" in the headphones.

The ZC1 was generally used with a vertical 34 foot long rod antenna, which was supplied in a number of sections. The transmission range was quoted to be between 25 and 35 Miles in CW mode and around 10 to 20 miles, in vehicles with 8 to 12 foot whip antennas.

Wire antennas were also an option such as an inverted L or T shaped wire. One feature of the ZC1 is a large 2 inch diameter output antenna tuning coil with many taps, which allows a significant range of different antennas to be used. This large coil with the brown former can be seen in the photo above, sitting above the chassis and about 2 inches behind the front panel and switches which select the coil taps.

The 6U7G tube was used extensively in both the transmitter and receiver sections. It made sense to use the same tube type for as many applications as possible in the one radio, to save on carrying different spare parts.

The transmitter tube line up is a 6U7G microphone amplifier V1G, and a 6V6GT Class A modulator V4B. The transmit VFO is another 6U7G V1F, followed by a 6U7G buffer stage V1E and a 6V6GT RF output stage V4A.

Generally the 6V6 tube is capable of around 2 to 4 Watts RF (or audio) output power in single ended applications. These tubes were popular in domestic radio audio output stages too and also used in Guitar amplifiers.

The Australian connection: 6U7's are a very capable RF Pentode. These were described by RCA as a "Triple Grid Super Control Amplifier". This means they are suited to applications involving AGC circuits and gain control. They were also a common tube type in the 1940's era. It was said that the 6U7 was the commonest tube to find in junk sales in NZ. The 6U7 is very similar to the 6K7 found in domestic radios of the time.

The 6U7 was abundant in Australasia and had many manufacturers, aside from the usual RCA, Kenrad, National Union, brands. Australian Philips made them too for the department of defence and supplied them in very attractive boxes with Art Deco artwork:

The 6U7G RF Pentode.

The D↑D logo engraved on the 6U7G tube base indicates that these tubes were made for the Australian Department of Defence and the arrow is the British Broad Arrow, often found on Military property.

The receiver arrangement in the ZC1 is that of a single conversion AM Superhet radio, with a BFO added, based on a 6U7G pentode V1D. The tube line up is a 6U7G RF stage V1A, a 6k8G Triode-Hexode converter V2A, a 6U7G 465 kHz IF stage V1B. Followed by a 6Q7 detector and 1st Audio pre-amp stage V3A.

The receiver's sensitivity was quoted at 1.5uV on 8MHz and varying above and below that over the bands a little and being 3uV on 2MHz. However, the output level was not stated, though probably it was in the order of 50mW, or similar into the headphones, or a 100 Ohm dummy load.

Audio Output Stage: The audio output stage is only designed to drive headphones, so the designers deployed yet another 6U7G RF pentode V1C, in a triode connected configuration, to act as the audio output tube.

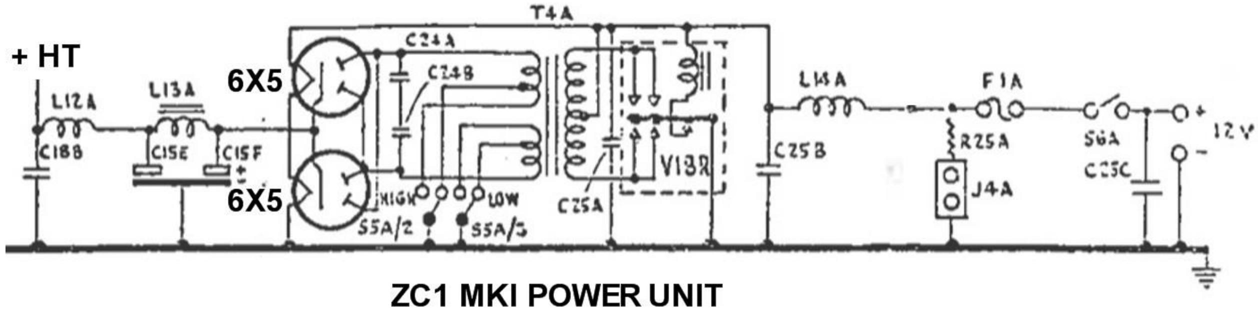
The audio output power of a ZC1 is a mere 50mW distortion free, but fairly distorted with 150mW output, pushing the 6U7G RF tube to its limits in this application, where it does not normally serve. This result is satisfactory for the 100 Ohm headphones used and speech, but not so good for an extension speaker and/or music though. Interestingly, some historical articles had mentioned distortion in the audio. The main cause for it, aside from the non-linearity of the grid voltage versus anode current transfer function, is that even by 100 to 150mW output, the 6U7G is driven into g1 grid current by the high drive level exceeding its bias voltage.

ZC1 MKI and MKII differences:

The MKI model was a single band 2MHz to 6.5MHz Transmitter & Receiver. The MKII version was split into two bands 2MHz to 4MHz and 4 to 8 MHz. Other differences include that the MKI model did not have an MCW transmit mode (see below).

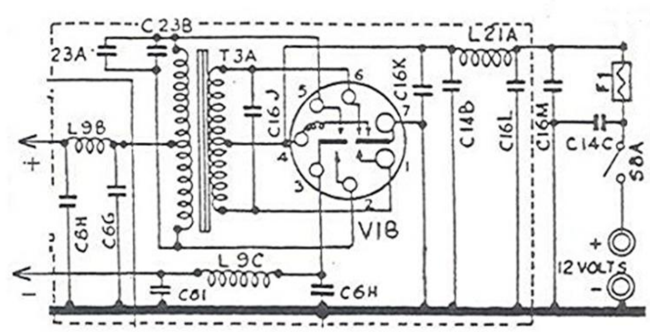
This is not the topic of this article, but briefly, apart from the separate bands on the MKI unit, the main difference between the MKI and MKII units is that the MKI unit used a non-synchronous Vibrator supply and instead two 6X5 tubes as the HT rectifiers.

Also in the MKI unit, there was a switch to select higher or lower level HT:



ZC1 MKI POWER UNIT

In the MKII however, the switch was dispensed with and a synchronous vibrator, the model V6295, deployed and the 6X5 tubes were dispensed with too:



ZC1 MKII POWER SUPPLY

The negative output of the MKII supply is connected via resistors to ground, so that a negative voltage of around - 50 to -60V is developed across these. This is used to cut off the tubes in the transmitter section when the radio is in Receive mode. In Transmit mode, the resistors are shorted out and this also boosts the HT voltage by an additional 50V.

With age, regardless of whether a Vibrator is a synchronous type, or non synchronous type, the contacts fail to make adequate connections with each other, for a number of reasons, degrading the reliability.

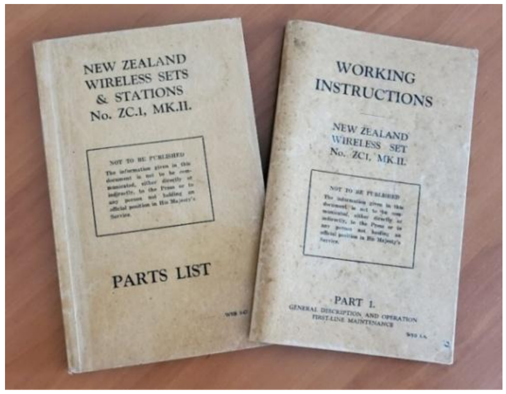
Over the years I have trialled many types of electronic and electro-mechanical vibrator units in my ZC1's. In the historical photo below, from the 1980's era, some early research versions of electronic V6295 units are shown. Item A is an oscillator driven type with 2N174 output transistors. Shown in B is a self oscillating type. This design uses feedback from the ZC1's own vibrator transformer to operate. This is the type I prefer. This design confers overload and intrinsic short circuit protection to the supply. It also results in very low transients on the transformer's primary terminals, without the need for additional primary tuning capacitance in the order of 0.47uF. This is required for all oscillator or *u*P driven units, though many designers neglect to include this additional capacitor.

Item C is the original V6295 vibrator unit. These always require repairs to run, even when unused, because of the degrading Latex rubber in the unit, which coats the contacts with a sticky film.

The unit at D is a 24V synchronous unit, modified to 12V operation. It may not be widely known, but if a 24V unit uses a separate coil contact to sustain oscillations and drive its vibrating reed from the 24V source, it can be re-wired internally to operate on 12V. The coil is connected to one of the primary contacts instead. This works because the transformer primary steps up the drive voltage to 24V. Item D is a generic 7 pin 12V unit made by Plessey.

The photo below shows the final design of the self oscillating units that I settled on and I manufactured a batch of them to use in the ZC1 MKII’s :

The ZC1 came with comprehensive working instructions and Part’s Lists with detailed diagrams to show and identify every part in the receiver. There was a lot of emphasis on easy access and being able to repair it (not something we see today).



The picture below shows a typical setup, from the working instructions manual of a ZC1 MKII radio in the field, with a vertical whip antenna. And another setup in a back of a truck for the mobile application:

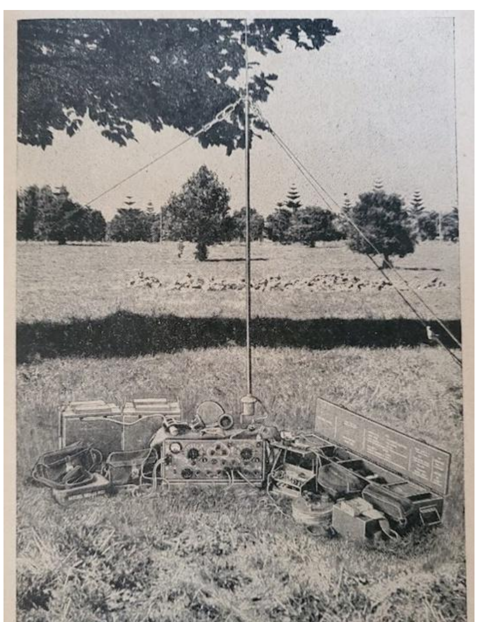


PLATE 3.—GROUND STATION.

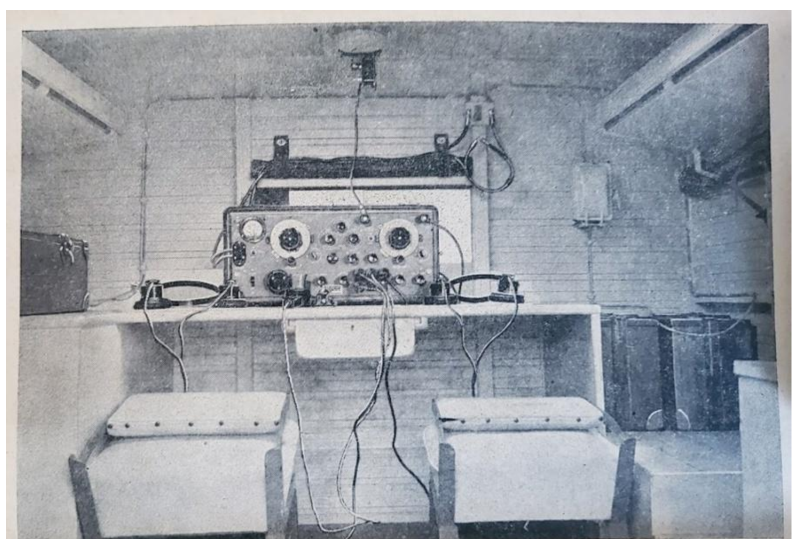


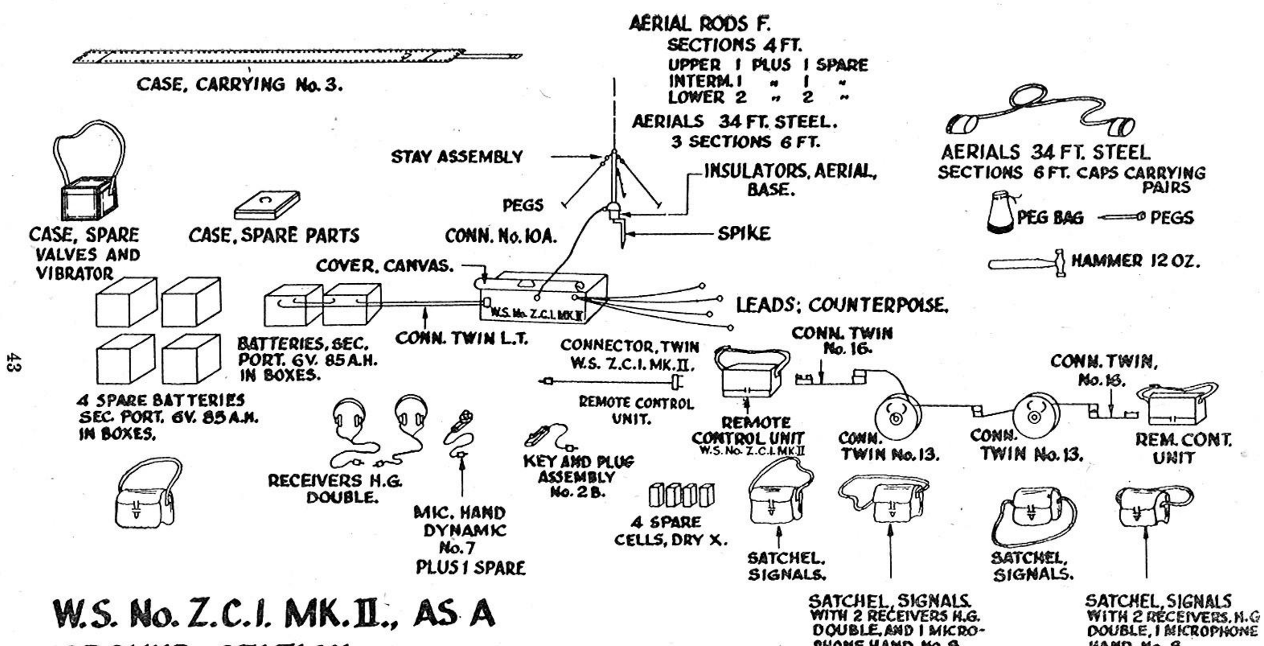
PLATE 2.—MOBILE STATION.

As well as part's lists, the manufacturers also supplied the Army's Signal Engineers with comprehensive details about the radio that were never generally supplied for domestic radios.

For example, detailed descriptions of each of the coils and transformers, which included things such as the exact number of turns used, the size of the former, the type of wire, the SWG wire size, the inductance value with the % tolerance and whether the coil was wound bifilar. The DC Resistances of the inductors was also documented. I have not seen this done before, in this level of detail, for any other radio that I own. It also means that in the future, if any of these fail, it would be an easy task to replicate them. Also the coil base diagrams were included too. As one would expect the voltage on every tube electrode is also well documented in the manuals.

ZC1 Accessories:

The ZC1 came with a number of. A very large number of items supported its use as a ground station. Less were required for a truck mobile installation:

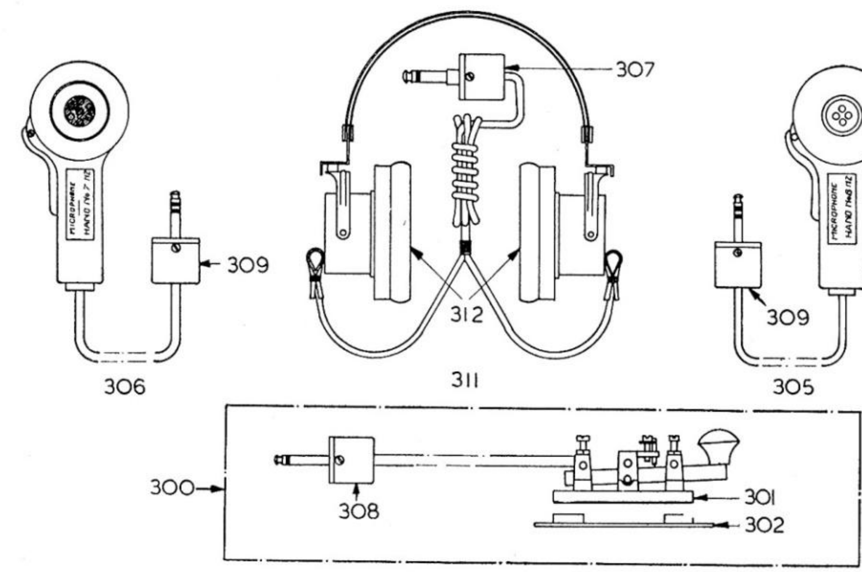


W.S. No. Z.C.I. MK.II., AS A GROUND STATION.

FIG. 10.

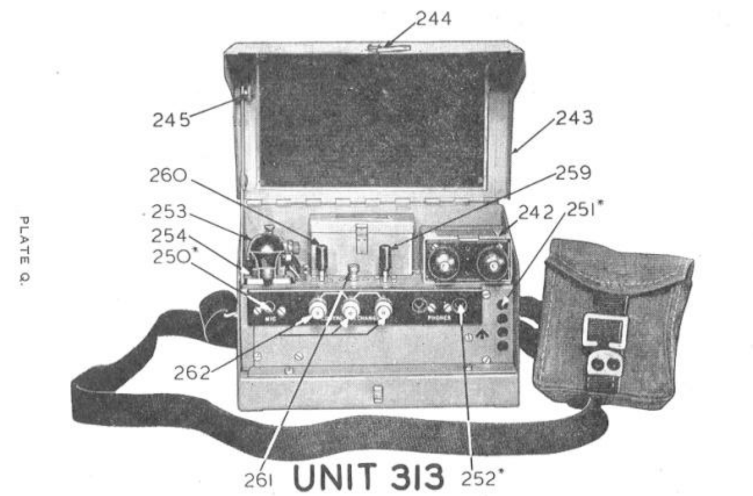
The minimum requirements aside from the batteries and the antenna, was obviously the Headphones and the Microphone and the Morse Key. The headphones and microphone were Dynamic types.

PLATE Y.



The picture below shows the actual microphone and headphone set that came with the ZC1. Both are dynamic type inserts, with a DC resistance of around 40 to 45 Ohms and the headphones and microphone have the same inserts. The ones in the headphones are wired in series and have a total resistance of around 95 Ohms and an impedance close to 100 Ohms @ 1kHz.

Other items included a remote control box for the radio, the Whip antenna kit, the battery pack and a spare tube kit, which contained every tube and a spare V6295 Vibrator unit. And then of course there were two 6V Lead-Acid 80Ah accumulator cells in wooden boxes.



ZC1 MKII REMOTE CONTROL UNIT

The remote control units allowed the ZC1 to be operated from at least 100 meters away on a connecting cable. Two remote control units could be used too, and the operators of those could talk to each other as though it was a telephone link. The remote control units came with a satchel to carry the microphone and headphones.

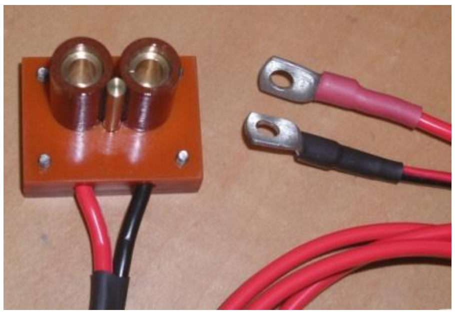
In addition an add on power amplifier type ZA-1 was an option, which incorporated 807 power tubes to boost the RF power. Not nearly as many of these booster amplifier units were made as the ZC1 radios.

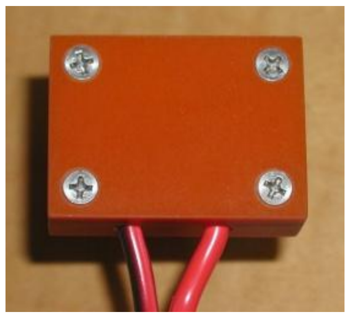
ZC1 12V Power Cord:

One of the interesting and tricky parts to get for the ZC1 these days is its polarized 12V power cord and plug. The original type was a substantial black phenolic connector and it used two large diameter rubber covered wires.

I hand made a compatible 12V plug with help of the Lathe. This is shown in the photos below, from some phenolic plate, machined Brass inserts, some electrical insulating tubes and Brass rod.

A friend, in the USA, also made a CAD file to 3D print this connector too.





Replacement Connector & DC power cable:

Restoring my ZC-1 MKII Radios:

I had replaced the electrolytic capacitors over 30 years ago in my ZC1 radios.

The ZC1, being made “Mil Spec” quality, it turned out that the other capacitors, which included wax paper types and moulded Mica types, when the radio was about 50 years old, remained in good condition. But that was 30 years ago. And now these capacitors are were about 80 years old.

On re-testing I found all of the capacitors had deteriorated, including the Mica types, nearly all had developed measurable electrical leakage.

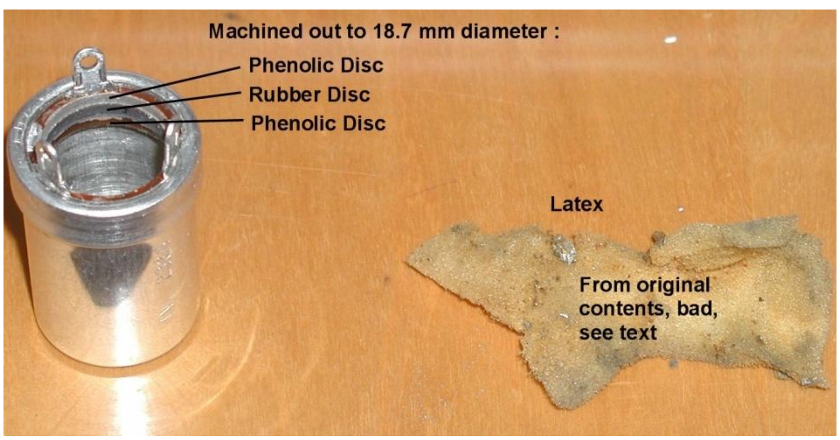
One reason why the wax-paper types had been better than most, is that they were sealed inside steel canisters with an additional waxy-oil, which kept the moisture out. These were capacitors were custom made in NZ and they did a fabulous job on them. They are the longest lasting wax paper types I have ever seen.

However, over time, the rubber seals failed where the canister and the phenolic end disc mated together and the lower molecular weight part of the oil or wax started to leak out, in addition, electrical leakage could be detected on testing as well.

Many of the Mica caps in the ZC1 were custom made by Radio Corporation and many were American types made by El-Menco. These were also amazingly good for their age. It probably helped them that in the ZC1 they were "Tropicalised" with a coating of wax over the Mica capacitor's plastic body.

In the ZC1 MKII they used three 1" diameter twist lock electrolytic capacitors.

For these capacitor replacements, twist lock types are sometimes available in 1" diameter as new manufacture. Of late though, this size, unfortunately, has been more difficult to acquire as a new part. I tend to re-build these types using the methods shown below, using a donor old stock capacitor with the base machined out and the innards discarded:



I generally start by machining out the base of the capacitor on the Lathe. If any Latex rubber is found it must be discarded and the inside of the canister cleaned, latex can contain Halides which attack aluminium.

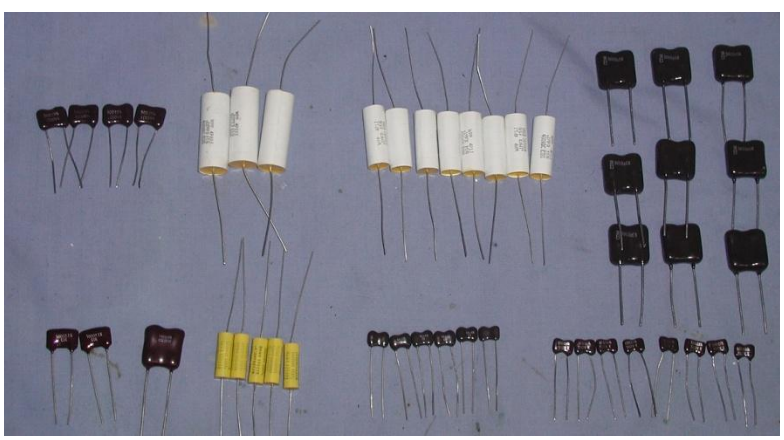
In vintage radio restorations, people often replace the original chassis mounted capacitors, with radial or axial types under the chassis. I don't subscribe to that as it looks non original and messy.

The general principle of how I do this is indicated in the photos below. A 10mm thick plug made of phenolic material is machined to fit the hole created in the capacitor's base. And two 2.0mm metric threads are cut in the material for screws and lugs. Also holes are drilled beside those screws with a 1.0mm drill to pass the wires from the replacement electrolytic capacitors.

The plug is glued in place with 24hr epoxy resin. Don’t forget to label the polarity of the pins before it is assembled. I drill a small countersink and fill it with a dot of red paint. When a multi section part is required, the capacitors are stacked on top of each other in the canister and additional terminals are used.

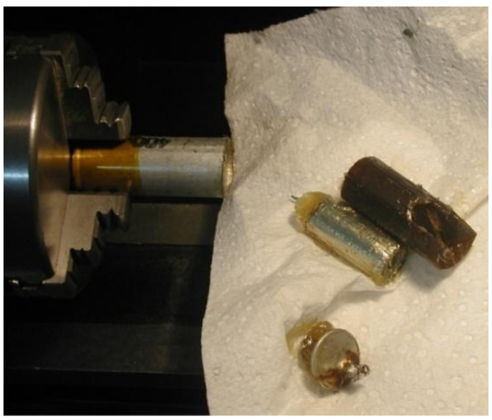
Replacing the original Mica & Wax-paper Capacitors:

There are a good number of Wax-paper & Mica capacitors in the ZC1 on account of it being both a radio and transmitter. It pays to order what you require first. I used new resin dipped 500V Silver Mica types and for the wax paper types I replace with Polypropylene film and these are fitted inside the original metal canisters.



For the wax-paper types in the ZC1, I found the better method was to unsolder the internal capacitor wire from the eyelet/tag at the end with the phenolic insulator. Then holding the capacitor (with protective tape around its body) in the Lathe chuck, carefully going around the circumference very near the far end, creating an initial groove with a junior saw.

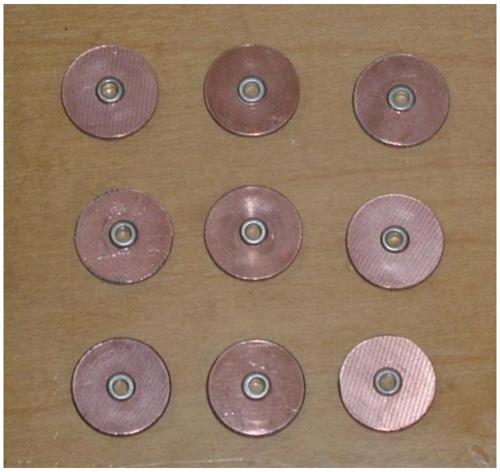
After that to cut off the end with the saw and slide the capacitor contents out of the canister (It is more risky using the Lathe's cutting tool for this as it can bite into the thin material). The end is then smoothed with a file while rotating in the chuck and then smoothed further with 400 grade paper.



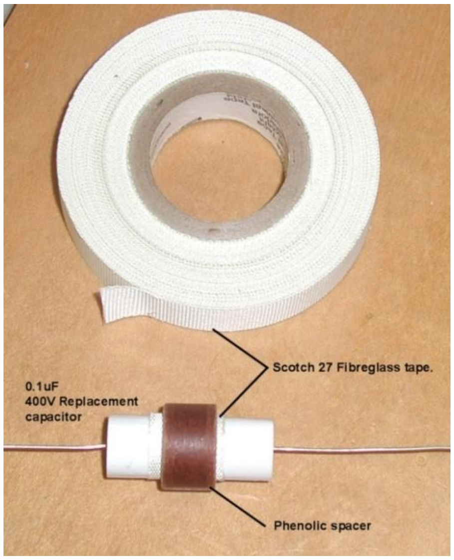
The photo above right, shows 5 of the cleaned out 0.1uF 400V capacitor canisters. Also the rivet and tag in the phenolic insulator is drilled out and discarded. I found these tags were in fairly poor order, the Brass being quite brittle where it was sharply folded and prone to cracking.

After that I fit 1/8" diameter silver plated brass eyelets to the phenolic end:

Then there is the issue of replacing the end of the capacitor which was cut off. A convenient choice is fibreglass pcb material. It is easily cut into discs using a 22mm diameter hole saw on the drill press. Then I make a 1/8" central hole and attach a screw & nut to secure it and rotate it in the lathe chuck. The perimeter is then machined down to 16.8mm to be a close fit inside the end of the metal canister. Again eyelets are fitted. The photo below shows some of the discs. The same principles apply to re-building the 0.2uF capacitors, except that I used a 25mm hole saw initially to make a larger disc. These discs are then also fitted with 1/8" eyelets:

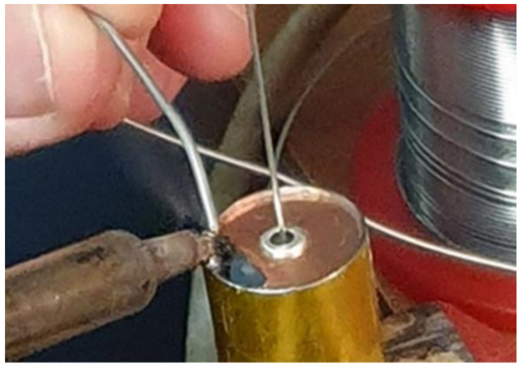


Then the replacement capacitor is prepared with a phenolic spacer and some Scotch 27 fibreglass tape, so it is a firm fit in the original canister:

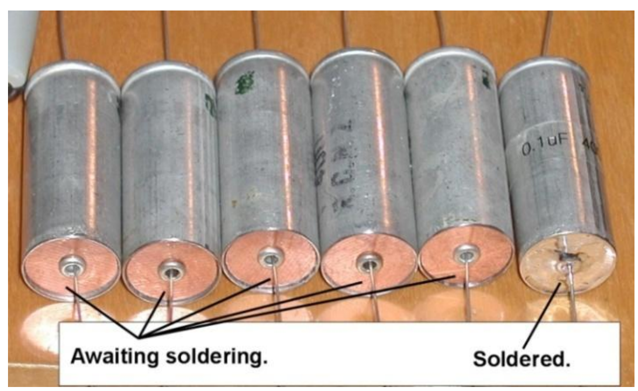


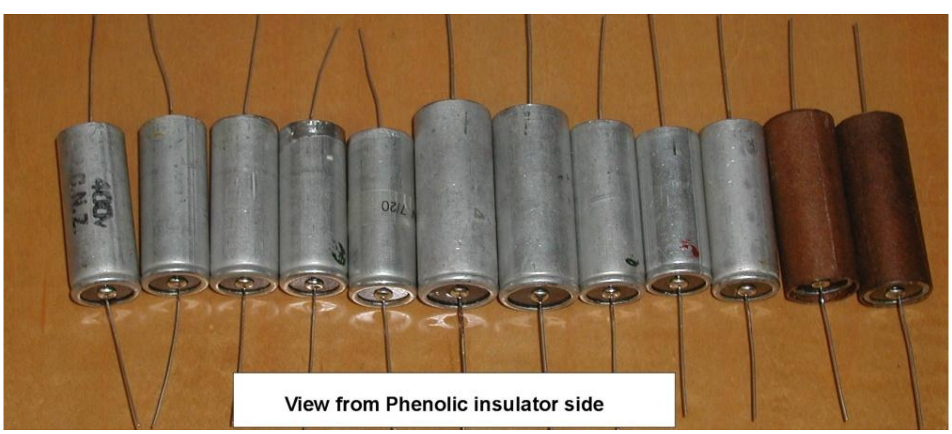
Soldering in the new end caps:

It is important to use the soldering iron (set on 400 Deg. C) to heat the edge of the canister around the 360 degrees initially to create a strong bond and then fill the well with more solder:



The discs are recessed about 0.5mm to 0.8mm into the end of the metal canister before soldering. This way a small well for the solder is created between the edge of the canister and the edge of the eyelet projecting from the copper side of the pcb material. This way a good amount of solder can be used. One very important thing: Polyamide tape must be wrapped around the capacitor body, right up to the edge being soldered or the solder will track down the outside of the canister, spoiling the appearance of the capacitor body:





When these capacitors were finished I put a clear surface label on these with the uF value and voltage and the date, to help remind me when they were re-built. Though it is unlikely they will need doing again. Also I decided that having flying leads on the capacitors was a better way to mount them than the original tags that they once had.

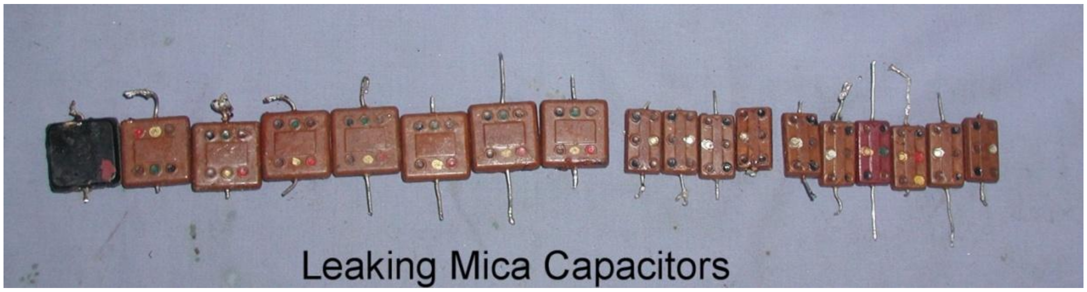
An interesting finding while restoring these capacitors:

The 0.02uF types were clearly custom made by Radio Corporation with a brown paper tube over them inside the canister, also filled with wax. But they must have been running low on their own production, because one of these capacitors turned out to be a Russian Doll, with a commercial capacitor inside the capacitor's tube. The photo shows the typical insides of the 0.02uF type with a plain brown sleeve:

But just one of the four capacitors had a commercial American made 0.02uF 600V "Dwarf Tiger" capacitor hiding inside it. So I re-built this capacitor and inserted inside the metal canister just as it was before.

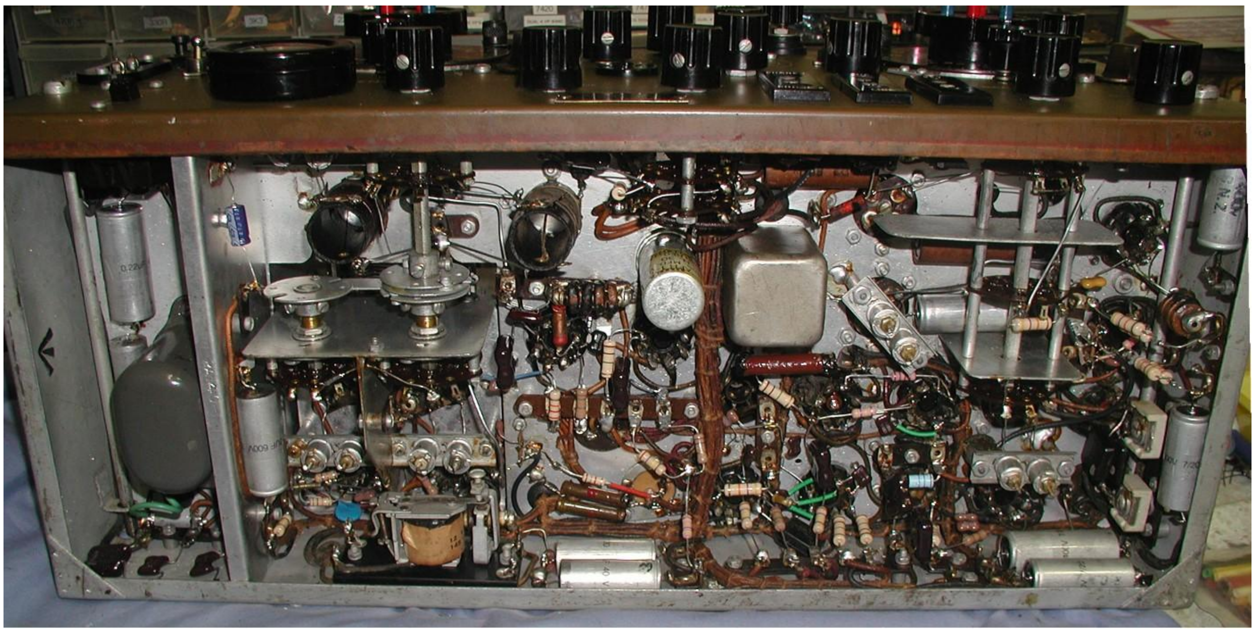
Dwarf Tiger Capacitor :

The photo bellows shows some (not all) of the Moulded Silver Mica types which were replaced with new high quality resin dipped silver mica types.

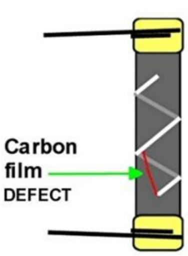


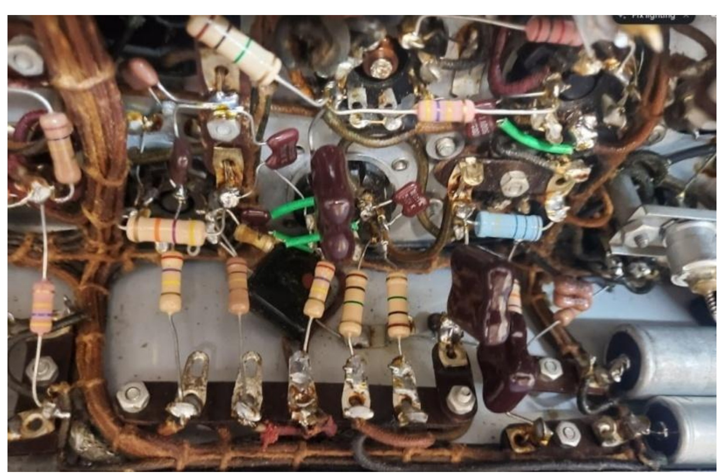
All the mica capacitors, bar just a few, exhibited some amount of electrical leakage at the 80 years of age mark, which is why they were replaced. Most were American made El-Menco parts. The black one, on the left in the photo above, was made by Radio Corporation from NZ sourced Mica.

The photo below shows the underside of the ZC1 after re-capping. Of note nearly every carbon resistor, except just a few in this radio were way out of spec and I had replaced them in the past.



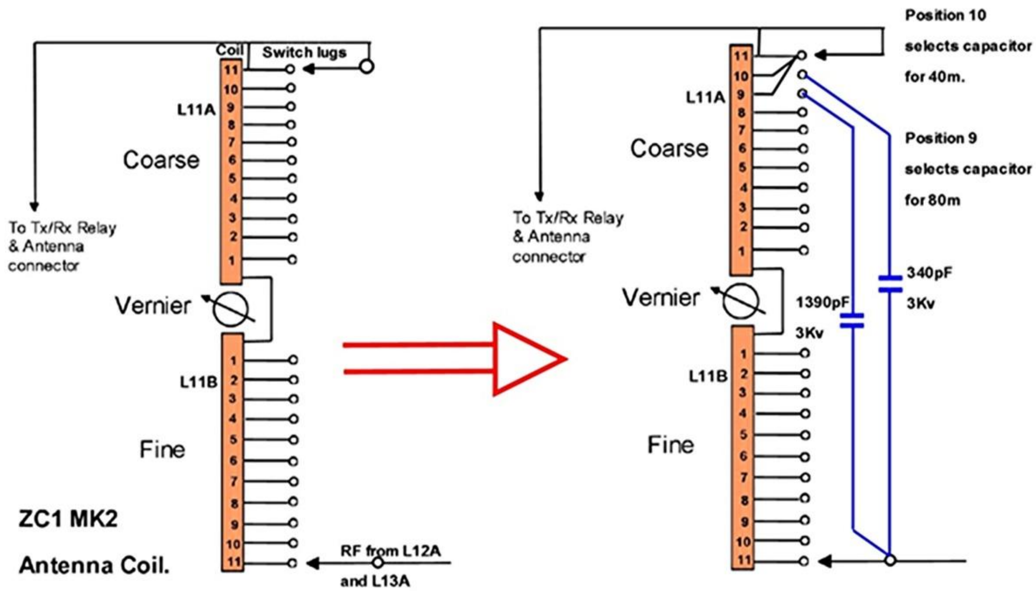
As well as many of the resistors being out of spec (gone high in value) one 50k power resistor had was open circuit. It operates in parallel with another 50k part to create a 25k resistor. To find out why this had happened, I carefully removed the paint to inspect it. It turned out that there was a discontinuity in the carbon film. The photo below right shows many replaced resistors and new Mica capacitors, though one of the Black NZ made Mica ones still remains.



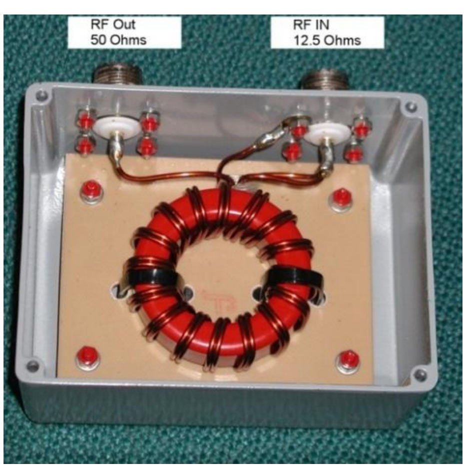


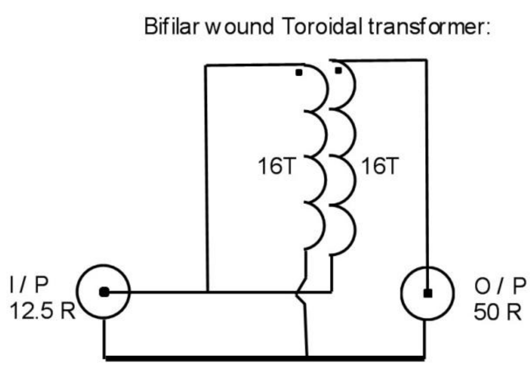
Getting the most out of the ZC1 on 40m and 80m Transmit Mode:

The RF output impedance of the ZC1 best suits long wire antennas. I found though by using a Balun and modified coupling to the output coil, the output could be optimized for a 50 Ohm load. This also makes it very easy to measure the output power with standard equipment. It requires the addition of two capacitors inside the unit and the Balun outside.



The capacitors are then selected with positions 10 & 9 on the switch. The Balun matches the then close to 12.5 Ohm output impedance to 50 Ohms. The Amidon core & wire comes as a kit part number AB200-10.

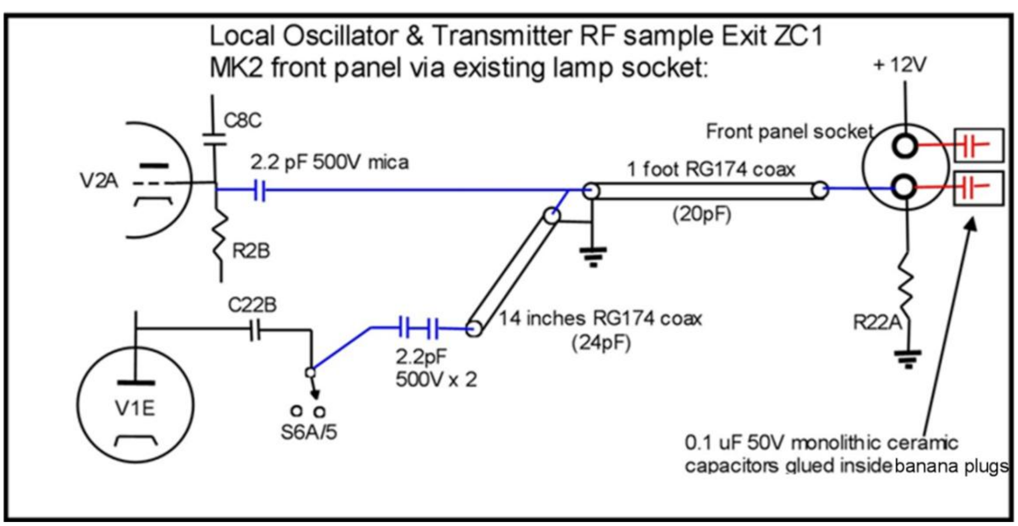




With this arrangement 2Watts is easily delivered to a 50 Ohm load on 40 Meters and around 3 Watts on 80m

Using a Modern Frequency Counter with the ZC1:

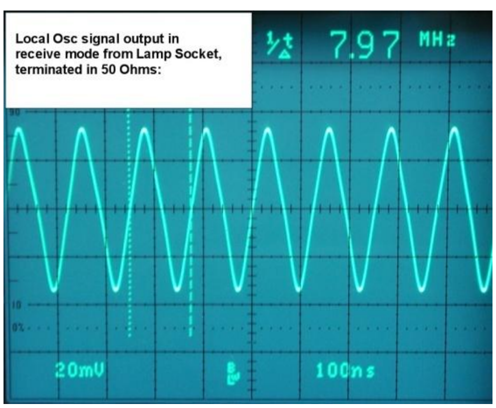
As previously noted, there is a connector on the front panel of the ZC1, used to power a reading light. One of its connections is via a resistor. By adding some coaxial cable into the radio, and small coupling capacitors, the signal from the Transmit VFO and the Receive VFO can be exported out of that connector.

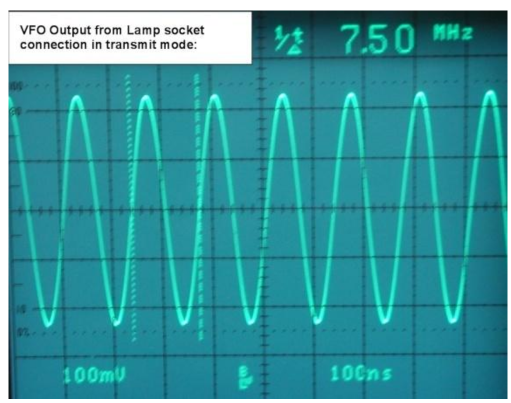


Due to the low values used in the 1 to 2pF range for the coupling capacitors the set barely requires re-tuning after these are added, C7G and C7H trimmers can be adjusted on the transmit side and C7C and C7B on the receive side(L/O) to fractionally reduce their capacity if required but I found it was not necessary. The capacitance of the coax forms an AC voltage divider and impedance transformation.

The presence or absence of the external frequency counter results in a negligible effect on receive or transmit frequencies. Since one of the connections on the lamp connector circuit is connected to positive and not ground it is a good idea to put two DC isolating capacitors in the banana plugs in case the chassis of the frequency counter and the ZC1 chassis come in contact. In addition the original function of the front panel lamp socket is not altered by this modification.

The following is a recording of the output terminated into a 50 Ohm load in receive mode with the radio tuned to 7.5 Mhz .The local oscillator of course runs 465 KHz (the IF frequency) above the received signal. The peak voltage is only 30mV, not all counters could accept that level and might need a buffer amplifier. My counter has an internal buffer/amp.





In transmit mode the output level is higher at just over 200mV peak. This is useful as the counter can be modified to switch out its 465 KHz offset in transmit mode, so it will automatically show the correct receive and transmit frequencies without having to manually switch the offset on the frequency counter.

Extension Speaker for the ZC1:

As noted, the ZC1 uses a 6U7G radio frequency tube (triode connected) as the audio output amplifier. Testing this circuit shows that designers pushed this tube to near its maximum ratings, which is a plate dissipation of 2.25 max watts and a screen dissipation of 0.25 watts, or a total tube dissipation of about 2.5 watts. The distortion increases significantly over 100mW audio output into a 100 Ohm load.

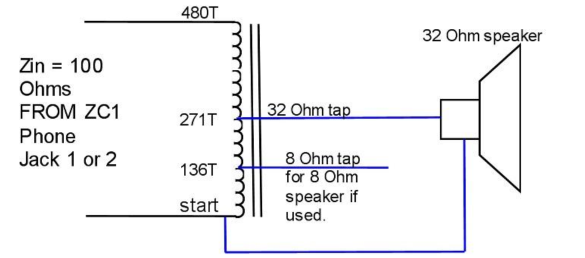
The 2K cathode resistor for the 6U7 can be reduced to 1.8k to gain a little more power, which is in the range for the specification of the original carbon resistor, most have gone high in resistance to the range of 2.5k to 3k. In addition if the tube is exchanged for a 6K7G, which has higher plate dissipation, but otherwise similar to a 6U7, the cathode resistor can be lowered to 1k2 which gives a good improvement.

Keeping the set original and trying a 32 ohm extension speaker gave a surprisingly good result. However, the impedance mismatch increased the distortion for any given power level.

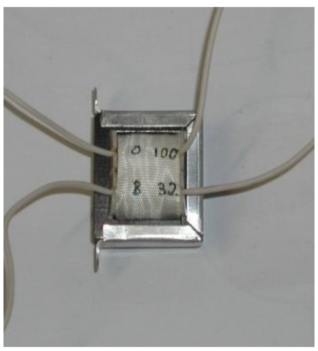
It is best to match the speaker with a small autotransformer, the design of which is shown below. The taps can be placed to suit any impedance speaker (remembering that the impedance ratio is the square of the turn’s ratio). At this low power level the laminated iron core transformer described here has a flat undistorted response from 50Hz to 20KHz.

Audio Autotransformer for ZC1 External Speaker:

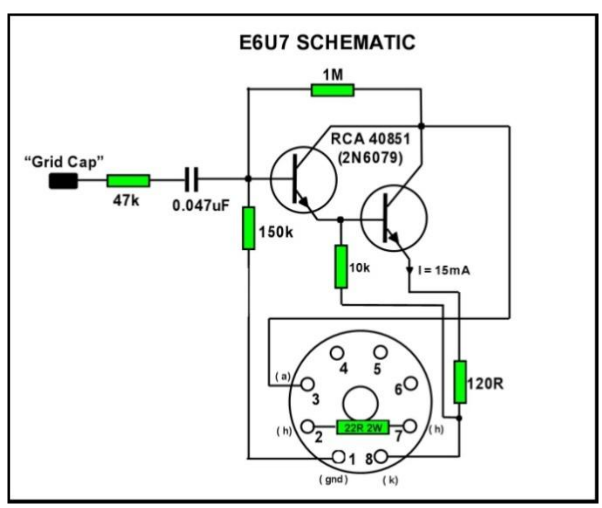
1 cm square inside the bobbin.
Total 480 turns of 0.315mm diameter wire(0.35mm with enamel)
Taps at 136 and 217 turns.
(DC Resistance of 480T = 6 Ohms).



The transformer was placed inside a speaker box, in this case with a spare 32 ohm speaker, however any speaker is ok with the correct transformer tap:



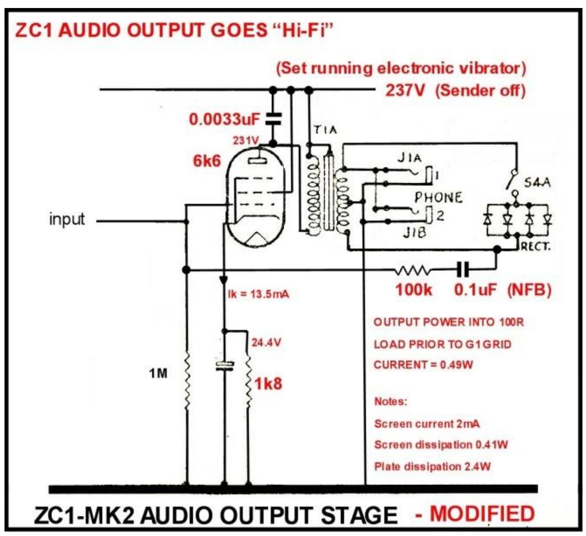
The output power can be increased by plugging in a transistor replacement for the 6U7G, which raises the output power to 500mW, and that works particularly well with this extension speaker. This gives a clean 500mW output, with no modification to the ZC1's radio's circuitry or wiring:



There are other options to increase the audio output power, including moving to a higher power rated tube such as a 6V6 or 6K6, however this requires modifications to the radio's circuitry and there is only so far the small output transformer's primary current can be pushed, likely over 18mA would be risky.

According to the data sheets, the primary of the transformer T1A has 3000 turns of 43 SWG wire. This wire has a current carrying capacity of only 18mA. Another option is an active external speaker, to boost the output that way.

The method of changing the 6U7G audio output stage to a 6k6 is shown here. In this case some negative feedback is added to reduce distortion too. It requires some wiring modification of the 6U7 socket though and it requires a balance resistor added across the tube's heater that it is in series with because of the higher heater current of the 6K6:



Summary:

The ZC1 MKII radio is a masterpiece of high quality radio engineering and a very impressive feat for New Zealand's Wartime Radio Engineers. It is so well built that it is not really surprising these still exist 80 years on. As one might expect, over that time frame, there is deterioration of capacitors and resistors. In my ZC1 radios at least, all of the coils and transformers remain in good order, as do the original tubes. The radio is a very good sensitive receiver for short-wave listening. It remains one of my favourite radios. Unfortunately, many that were deployed for Marine use, acquired significant rusting as a result, but with enough work that can also be remedied.

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