Refurbishing a Canadian Marconi Radio Direction Finding Set, Model MDF–5

Gerry O'Hara

A friend brought me his Marconi RDF set (Model 'MDF-5') to have its electronics refurbished – photo, right, without its impressive loop antenna system (as the loop antenna is currently fitted to the roof of his WWII vintage tugboat!). Maybe somewhat appropriately, the receiver looks to me like a cross between a sextant and a 1920's TRF radio…

The sloped front panel hinges down (photo below) to reveal the receiver sub-chassis attached to the left side of the front panel, and a variable capacitor, inductors and other parts on the right side of the front panel, plus some additional components mounted inside the cabinet. Central on the front panel is a dual-scale compass bearing arrangement which moves the rotating coil of a goniometer located in a screened compartment behind.

The good news from my initial 'once-over' of the set was that it seemed to be complete, although I noted that there was some tidying-up to do on the power connector strip (it was loose in the cabinet), plus the usual aged-component replacement, etc.

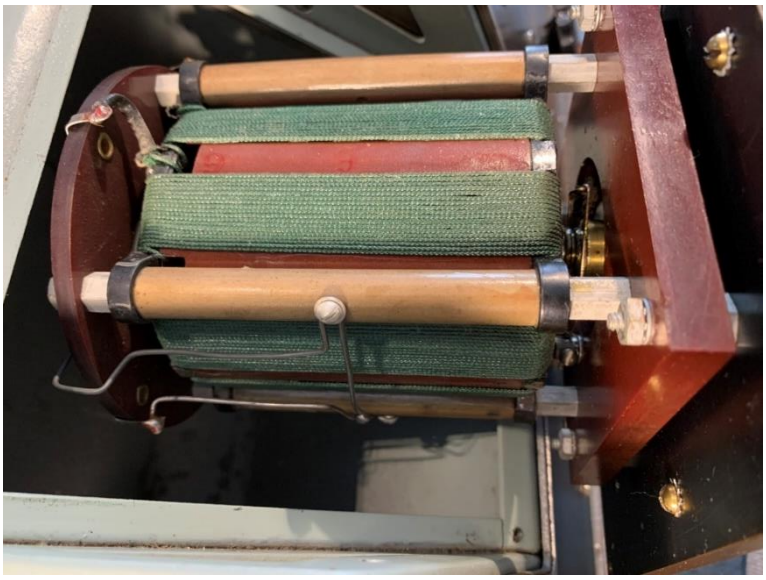
The Marconi MDF-5

The Marconi MDF-5 is a 'medium frequency' direction finding receiver with a frequency range of 265KHz to 670KHz that entered service around 1942. The complete MDF-5 unit actually comprises the Direction Finder (DF) receiver and the DF loop antenna. The receiver is constructed in a heavy-gauge sloped-front steel cabinet that has four compartments (one unoccupied): the receiver chassis is fixed to the hinged front panel and sits in the left compartment when the front panel is closed, with the other components

(used for the DF functions) mounted in the right and central compartments. Some of these components are mounted directly onto the front panel, others onto the base/sides of the cabinet.

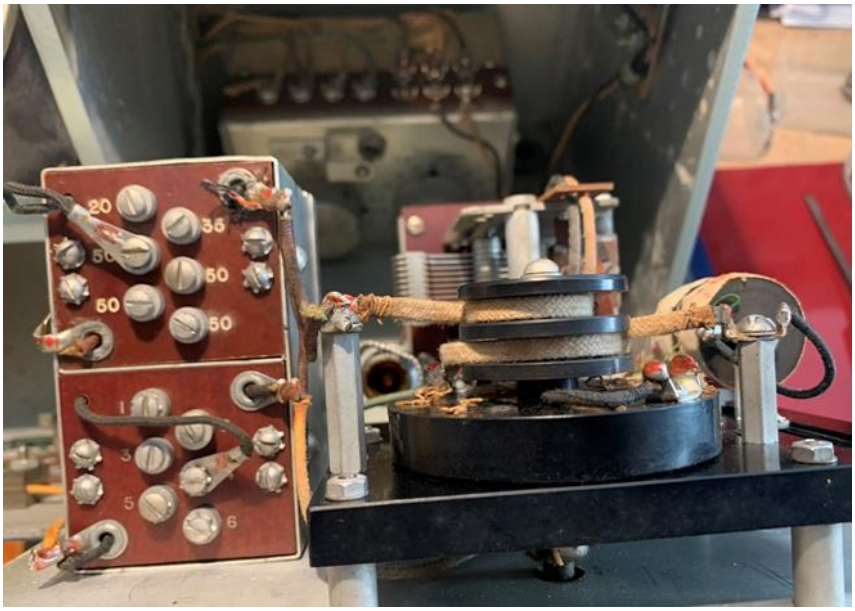
Receiver

The DF receiver comprises all the electronic components necessary for radio direction finding with the exception of the loop and 'sense' antennas, ie. a medium frequency radio receiver, a quadrantal[1] error corrector and a goniometer[2]. The radio receiver is a simple superhet design built on a compact chassis (photo, right), comprising an RF amplifier (1N5G), converter (1A7G), an IF amplifier (1N5G) operating at 175KHz, a 1st audio stage/detector (1R5G), an audio output stage (1T5GT) and a BFO (1G4G). Unusually for a set of this era, a permanent-magnet speaker is used, this being mounted internally on the right side of the cabinet. No AGC circuit is used, instead, the 'Volume' control is actually an RF/IF gain control, this varying the DC bias applied to the RF/IF tubes. This control incorporates a DPDT switch that switches off the 'A' and 'B' supplies to the set. The 120vAC dial lights are switched separately using a toggle switch mounted on the left side of the receiver cabinet (missing on this set). Other receiver controls comprise 'Main Tuning', 'CW/Off' (ie. BFO on/off - no BFO pitch control is provided), and a 'Speaker/Off' switch that disconnects the internal speaker when using 'phones' - there being two 'phones jack sockets mounted centrally on the front panel. The remaining controls are used for the DF functions, comprising 'Search Tuning', 'Balance' and a 'DF/Sense' switch, the functions of which are described below. The upper central compartment contains only the goniometer (photo, left), which is located directly behind the large direction indicator dial.



[1] A quadrantal angle is an angle in standard position whose terminal ray lies along one of the axes

[2] An instrument that measures an angle: in this application, a rotating coil ('sense' coil) within a set of fixed ('field') coils is fed with the signals from two crossed antennas (loops) to create an analog of the radio signal from the antenna. Rotating the sense coil in the field coils has the same output as rotating the entire loop antenna in the original field – see here and here for more information



The antenna section preceding the RF amplifier stage is where most of the DF 'magic' happens, and comprises the goniometer, the tuned search-coil circuit with its associated 'Balance' and 'Sense' couplings (photo, left. The 'Search Tuning' control tunes the goniometer search-coil circuit to the same frequency as set by the 'Main Tuning' control on the receiver. The 'DF-Sense' switch is used to determine the absolute direction ('sense') of the received signal. When switched to 'DF', two bearings will be obtained when rotating the goniometer dial, 180 degrees apart. When switched to 'Sense', only one bearing will be obtained, this being indicated by using the 'Sense' pointer on the goniometer dial. The goniometer dial has two scales: one fixed, the other rotatable: the fixed scale indicates the bearing of the transmitting station relative to the 'ships head' (bow of the ship), and is read with the 'Relative Bearing' pointer. The rotatable scale indicates the bearing of the transmitting station relative to true north, this being read with the 'Pelorus Bearing' pointer[3]. The 'Balance' control provides an adjustment for sharpening null signals when taking bearings, especially when the MDF-5 setup is close to the transmitting station.

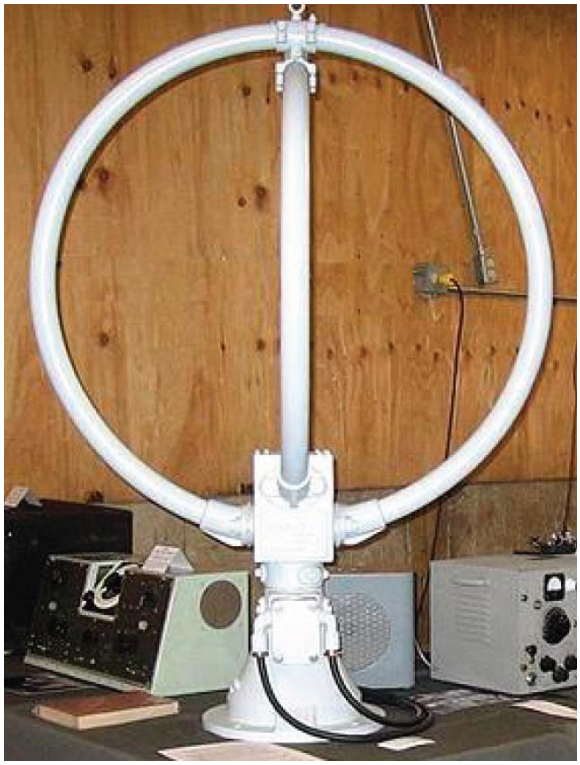
A 'Calibration Choke' (photo, right) is provided to assist in setting-up the DF circuits with the loop antenna. This unit is mounted on the base of the right-hand compartment of the cabinet and comprises a two-section choke tapped at various points, the taps being connected to two switches on the front of the unit. The purpose of this choke, when correctly adjusted, is to slightly reduce the output from the loop across which it is connected until the strength of the received signal from both loops is the same.

The MDF-5 does not have an internal power supply and so it must be connected to an external batteries or power supply providing a nominal 1.4vDC at up to 300mA ('A' Supply to the tube filaments), 90vDC at up to 9mA ('B' Supply for the tube plates/screens), and a 120vAC (or 120vDC) supply for the dial lights (these total 24W). The power supply

[3] A pelorus is a reference tool for maintaining bearing of a vessel at sea. On the MDF-5, the rotatable scale must be set so that the arrow on the inside of the scale points to the ship's course corrected to true north

connections are brought into the unit to a terminal board located inside the left-hand compartment of the cabinet.

Antenna Arrangement



The Marconi MDF-5 requires two antenna systems: a dual loop and a wire 'sense' antenna. Unfortunately, the loop antenna did not accompany the set[4]. A photo of the original loop antenna is shown right - I understand that this is the one that is now fitted to the owners tugboat. This photo shows it with this MDF-5 receiver in the background (to the left) on a display by the former owner of the receiver at an exhibition several years ago.

The loop antenna system consists of two shielded fixed circular loops at right angles to each other. The wires of each loop are contained within a metal (brass) sheath. The two loops are oriented Fore-Aft and Port-Starboard ('athwartships'). The loop assembly is mounted on a pedestal bolted to the superstructure of the ship, eg. roof of the bridge or radio room. One loop is 3'3¾" in diameter (oriented athwartships), and the other 2'5½" in diameter (oriented Fore-Aft). The manual notes that the loops are connected to the receiver using "…2-conductor No. 18 B&S copper wire, heavy duty with jute filler…" where the cable is less than 25' in length, and "…special paper-insulated lead-covered cable… run in metal conduit…" if greater than 25'in length.

The (vertical) 'sense' antenna is a simple wire, specified as "…about 25' long, measured from the deck insulator to the free end…", so not too critical compared with the loop installation – the location of the 'sense' antenna relative to the loop assembly is not specified in the manual.

Once the antenna system is installed and correctly connected to the receiver, careful set-up of the receivers RF circuits is required to prepare the set for DF operation – this is detailed in the manual. I checked-in with a former owner of the set and vintage RCN radio equipment expert to see how the RF stages of the set could be set up for correct DF operation without the loop antenna system. The conclusion was that cannot – it must be set up with the loop antenna installed where it will be used.

Scope of Refurbishment Work

The following scope was agreed with the sets owner:

- Secure the power supply tagstrip to the cabinet;

[4] The owner of this receiver has the matching loop antenna that is mounted on hi WWII vintage tugboat. It weights over 150lbs and he did not feel up to removing and transporting it (and I could not have lifted it anyway!)

• Continuity checks on coils, goniometer assembly, chokes, transformers, fuses etc;

• Replacement of all the paper capacitors (about a dozen) and electrolytic capacitor (there is only one). The owner has confirmed that he just wanted these replaced with modern parts rather than re-stuff the originals;

• Check resistor values and replace any that are significantly out of tolerance;

• Remove and test the tubes: these are all low voltage filament tubes (1.4vDC);

• Check wiring - I had note in the preliminary under-chassis inspection that some is rubber-insulated and if significantly degraded, it should be replaced;

• Clean the chassis, clean and lubricate tuning gangs, switches and pots;

• Replace any defective dial lights (the dial lights are 120vAc operated);

• Jury-rig some form of dummy loop antenna system to function-check the DF component operation;

• Pre-power-up resistance and leakage checks;

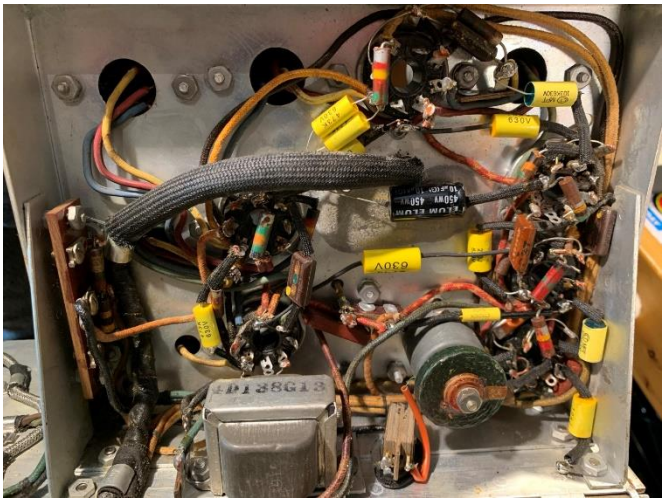
• Test operation using an external (bench) power supply, troubleshoot, alignment, etc. as far possible without the correct loop and sense antennas installed;

• Build and test a suitable external power supply; and

• Soak testing and further troubleshooting if needed.

Initial Refurbishment

All paper capacitors and the single electrolytic capacitor were replaced (photos right, before, and after, below), and the power supply/antenna hook-up tagstrip was fixed to the base of the cabinet using stand-offs. I decided to leave the chassis attached to the front panel for the capacitor replacement work – in hindsight, removal of the chassis would have provided better access but would have meant further disassembly/reassembly.

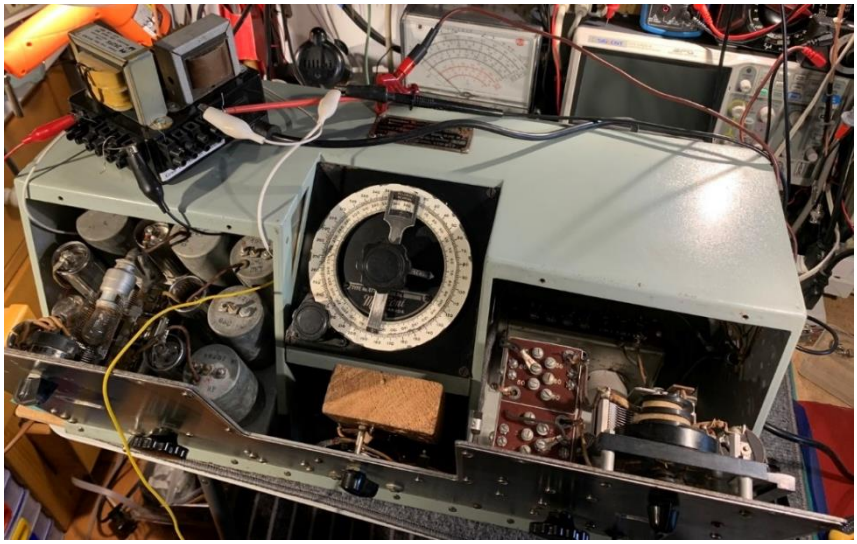


Removal of the tubes from the receiver chassis proved more than a little difficult – all, bar one, including their shields, were stuck firmly into their sockets. I have occasionally had a

recalcitrant tube, but never so many that required careful (but firm) manipulation to remove them – this probably took me an hour. All tubes tested good, though one tube, the 1G4G (BFO), had an intermittent cathode connection.

Continuity tests on the transformers, coils and chokes were all good, and only a couple of resistors measured slightly out of tolerance.

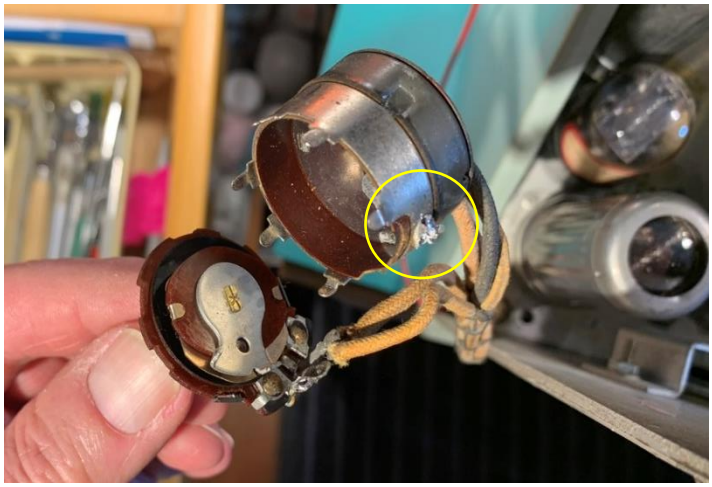
Power-up and More Refurbishment/Troubleshooting



An initial power-up test was next, using a homebrew bench power supply (photo, right). The receiver 'came to life' immediately – a video of this test can be viewed here. It was obvious that several controls need cleaning, the BFO did not work (likely the intermittent 1G4G tube), and the alignment needed tweaking (the tuning dials were off-frequency by several tens of KHz). However, it received the signal generator across the full range of the tuning (apart from the extreme upper end – re-alignment of the local oscillator would resolve this).

I picked up two tubes from our local supplier: a NOS 1G4G and a 'used, tested' 1A7G (the set had a 1A7GT installed and this meant the metal tube shield was too tall), and installed them into the chassis. The BFO now came to life, though I found the BFO on/off toggle switch was both loose and was upside-down, as well as being somewhat intermittent in operation. Also, it appeared that the converter (1A7G) tube socket had been changed-out at some time and the replacement was missing the metal skirt that couples onto the screening can: thus when the screening can was installed over this tube, it made only intermittent contact with the chassis. I realized that this could be why a metal-skirted 1A7GT tube had been used - the metal skirt around the tube base is coupled to pin 1 of the octal socket and this is grounded to AC on this chassis. I decided therefore to leave the 1A7GT tube in place and tweak the screening can to better-accommodate the top cap lead to the tuning gang.

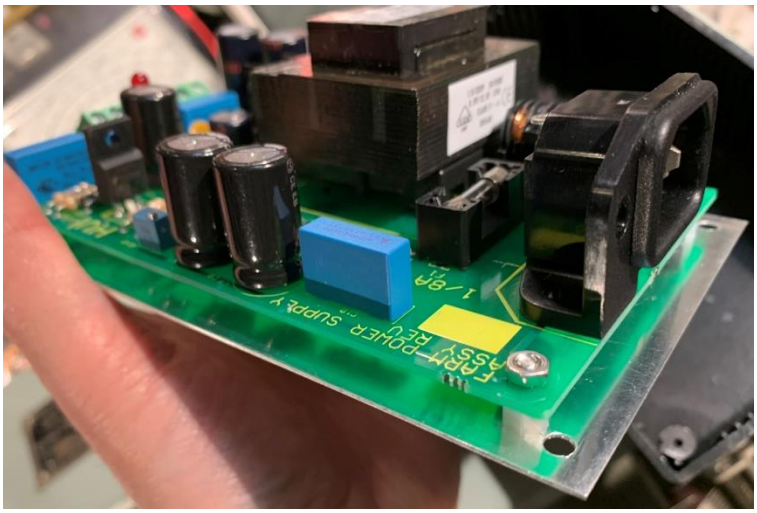
I then disconnected the wires from the BFO toggle switch and removed it from the front panel - easier said than done as the retaining round 'nut' was cross-threaded and the serrations around its edge were well-worn. I have the correct tool for this type of serrated round nut – even so, it took around 30 minutes to remove it without damaging the front panel. I squirted some Deoxit D5 into the switch (around the toggle ball) and worked the switch several times – that the cured the switches' operation. I re-installed the switch the correct way around, including a serrated washer between it and the rear of the chassis to make sure it did not rotate, and soon realized why someone had installed it upside-down – the wires cannot be easily installed with the switch oriented that way. So, I had to remove the switch again and attach the wires first, then re-install it onto the panel. I also cleaned the speaker switch and installed a serrated washer as that switch was also loose.



The volume pot was removed from the front panel and opened (photo, right) to clean the carbon track with Deoxit 'Faderlube', and the integral switch with Deoxit D5. After reinstalling the volume control, the set fell silent – almost: the IF and AF stages were still working, but as soon as the IF amplifier grid cap was attached it silenced the receiver. This 'fault' was traced to me forgetting to re-attach the 'cold' end of the volume pot to the body of the control (ground) – circled yellow in the photo, right). In a 'normal' set, this would likely have caused the set to be at full volume, but in this set, the 'volume' control is really an IF/RF gain control, and without a ground on one end of the pot the RF amplifier, converter and IF amplifier were all being biased off, hence silence… Soldering the cold end of the volume pot to its case soon cured this.

I then re-wired the power supply connections, using a short length of shielded multicore cable threaded through the rear of the chassis to provide the required connections from the homebrew power supply - much better than the initial jury-rigged alligator clips and flying leads.

Power Supply



While looking for parts to build a power supply for the owner of the set, I remembered that I had bought a couple of excellent professionally-made power supplies some years ago from a friend who had bought up the remaining stock of these from an outfit in Seattle that were stopping production - these were being sold as 'Farm Set' power supplies (photo, right).

I had used one of these power supplies in a small domestic set (a Phonola) a few years ago, and the second one was earmarked for a 'future project' – I realized that the Marconi RDF set was that project.

This power supply is ideal for this application, providing very well regulated and filtered nominal 1.4vDC for the filaments ('A' supply) at up to 350mA, and nominal 87vDC for the plate circuits ('B' supply) at up to 50mA – the latter can be adjusted from around 82vDc to 89vDC. My initial thought was that I may be able to build the power supply into the MDF-5 cabinet rather than into a separate box, there being a fairly-well screened unused compartment in the cabinet beneath the goniometer. The power supply

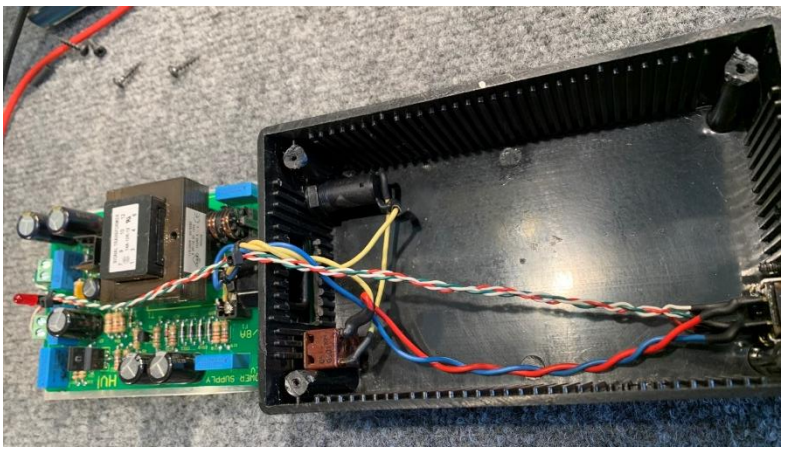
board fit neatly into the space, however I identified a few potential issues that would/could arise fitting the power supply into the cabinet:

- This is not a 'normal' radio and there was probably a reason why there was not a power supply installed internally: one could possibly affect the RDF functionality or induce interference, eg. by having a power transformer in close proximity to the DF coils and goniometer;

- I note that the 120vAC-powered dial lights all have shielded cables, and the internal fuse box for the dial lights is also shielded and has a huge suppressor capacitor unit inside – this suggests that the RDF circuitry is likely sensitive to mains-born RF interference;

- Although the PCB-mounted power supply fitted neatly inside the unused central compartment, and would thus be reasonably well-shielded from other parts of the radio that may mitigate the above, it would require either some difficult and undesirable butchery of the cabinet to allow the PCB-mounted IEC connector to be used. Alternatively, I could 'hack' the AC line connections by directly wiring to the rear or the IEC socket to avoid using the IEC line connector, but did not really like this idea.

So, instead, I decided to install the power supply PCB into a project box so it was kept separate to the receiver (photos, right and below). I found a new ABS project box with a metal lid that was a good fit. The printed circuit board was attached to the metal lid, which would become the base of the unit. A power switch and fuse were installed, along with an opening to insert the IEC line connector into one end. The power



supply has a flashing LED to indicate when power is being applied to the receiver and to allow this LED to be seen, a hole was drilled in the box next to the LED and a translucent stub of nylon used to plug the hole. A 6-way 'Cinch' ('Jones') socket was also installed at this end of the box to connect to a short umbilical shielded multicore cable to the receiver (captive at the receiver end). This provides the 1.4vDC filament, 87.5vDC plate and 120vAC dial light supplies to the receiver.

I replaced the (missing) dial light toggle switch that would have been installed

originally on the left side of the cabinet (pilot light on-off), using the original hole to mount the switch. I disconnected the large (twin 0.5uF) suppressor capacitor on the120vAC dial light supply as it was grounded to the cabinet and would have given anyone that touched the cabinet a real 'tingle' if the cabinet was not properly grounded (the cabinet is deliberately not grounded through the power supply – it needs a proper 'physical' ground, ie. connecting to the hull of the ship on which the receiver is installed). In its place I installed a single X2-Class 0.47uF 275vAC working safety capacitor across the line inside the screened fusebox. The set was powered-up using the newly-constructed power supply and functioned well – subsequent testing confirmed that I made the correct decision regarding mounting the power supply externally – see this video.

Next steps included re-checking resistor values having had the set operating for a few hours - I replaced a couple of out of tolerance resistors, and re-alignment of the IF and RF stages per the manual – all very straightforward. Both the IF and RF stages were significantly out of alignment – following adjustment the receiver section was performing within its specifications.

Function Testing the DF Sections

I jury-rigged a dual loop so I could undertake some limited function testing of the DF section or the receiver: I made the two loops from RG-58 coax to the correct dimensions, and then coupled them to the set using a short piece of screened multicore cable. The braid of the coax (both loops) were coupled together and grounded to the set via the screening sheath. The inner conductor of each loop was connected to the correct terminals on the Calibration Choke via the inner conductors of the multicore cable. I mounted a block connector on the rear apron of the set for this purpose (fixed with sticky pads to avoid drilling the cabinet). I also added a short 'flying' coax lead terminated with a BNC line socket onto the sense antenna connection for ease of connection of the sense antenna without modifying the receiver cabinet – photo, above. The video here demos this setup.

I corresponded with three friends that are 'in the know' about RCN radio equipment and operation practices, and with some knowledge of the MDF-5. They were able to provide me with the correct loop dimensions, and they agreed with my conclusion that there is no way the DF circuitry, eg. tweaking the Calibration Choke, can be correctly set up without the actual (specific) on-ship installation of set, sense antenna, correctly-oriented loop antenna and the correct type of cable between it and the set. That said, per the video, I think everything seems to be functioning as it should do in that regard.

Finishing-up

There were a few minor details to complete before the set was ready for collection by the owner, namely:

- Adding a sleeve to the grid lead of the 1A7GT converter tube to the tuning gang where it passes through the slit in the 'too-tall' metal shield to prevent chaffing (photo, right);

- Drill some vent holes in the power supply box above the voltage regulators (it was becoming slightly warm after an hour or two use powering the set);

- Fabricate and install some labels and feet onto the power supply box; and

- Locate a suitable replacement dial light – I found one in my 'junk box' with a slightly larger bulb size than the original ones – its wattage was not indicated, but the base was the correct type. It looked like a kid's 'night light' bulb, and when fitted was of similar brightness to the original dial lights. The DF dial is now fully-illuminated via the quarter lights either side of the dial (photo below, left).

I also improved the jury-rigged loop antenna – I used some garden canes to spread the loops out and set them at 90 degrees to each other (photo, below right). Running the set with this arrangement improved interference rejection using the Balance control – see video here. It would certainly be interesting to see how things would work with the correct loop and sense antenna installations on the owner's WWII vintage tugboat – maybe one day - at least I don't get sea-sick…

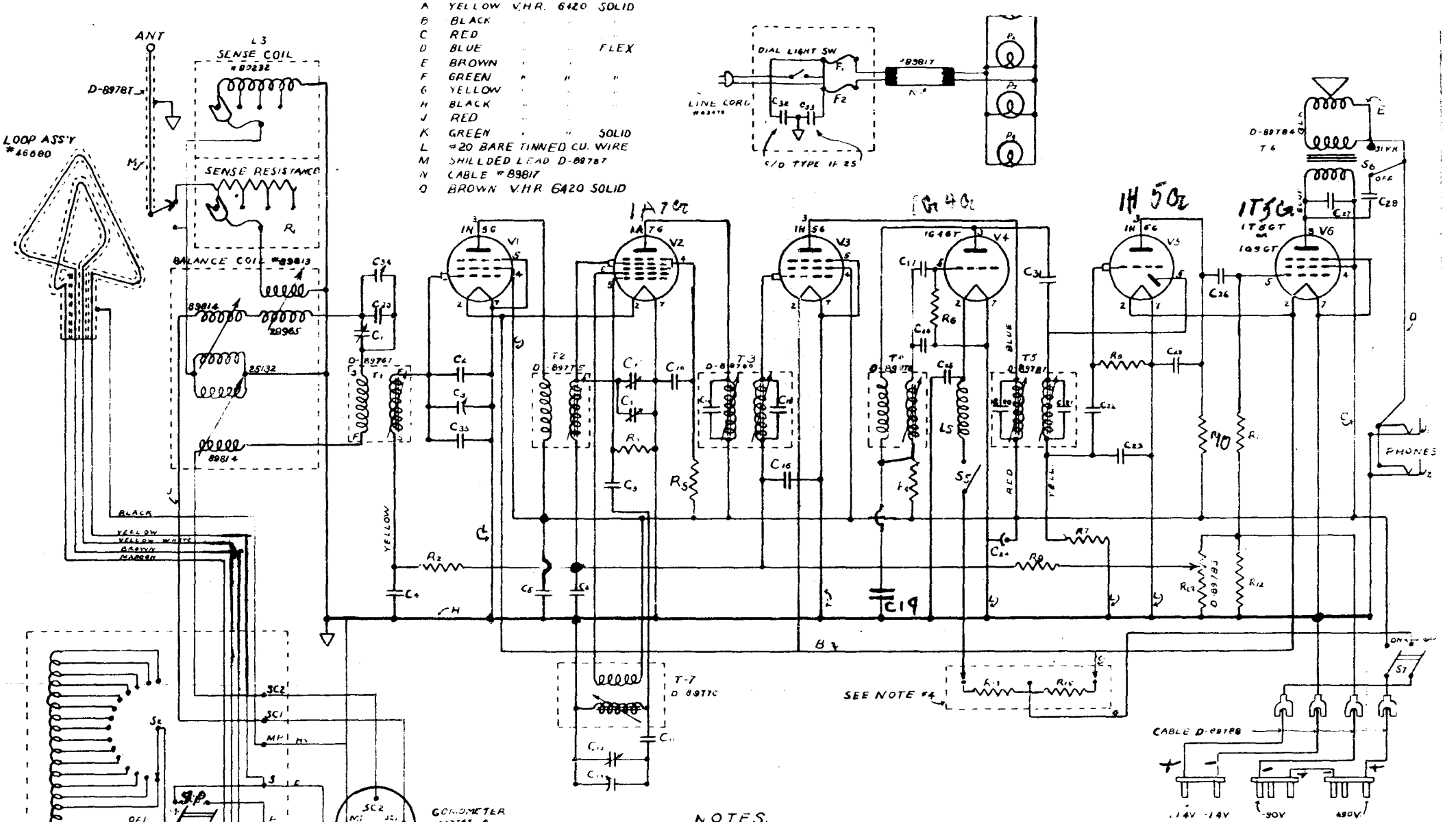
The refurbished Marconi MDF-5 direction finding receiver with the power supply sitting atop

APPENDIX

- Schematic of the Marconi MDF-5 Receiver
- Marconi MDF-5 Connections

WIRE LEGEND

A	YELLOW V.H.R. 6420	SOLID
B	BLACK	
C	RED	
D	BLUE	FLEX
E	BROWN	
F	GREEN	
G	YELLOW	
H	BLACK	
J	RED	
K	GREEN	SOLID
L	#20 BARE TINNED CU. WIRE	
M	SHIELDED LEAD D-89787	
N	CABLE #89817	
O	BROWN V.H.R. 6420	SOLID



NOTES.

1 - INTERMEDIATE FREQUENCY - 175 KC.
2 - SWITCHES S1 & S2 SHOWN IN ANTI CLOCKWISE POSITION.
3 - LETTERS ON COIL ASSY'S INDICATE START AND FINISH OF WINDINGS.
4 - IF A 1.4V A BATTERY IS USED CONNECT BLACK & RED LEADS TO THE CENTRE TERMINAL
IF A 2V A BATTERY IS USED CONNECT THESE LEADS TO THE TERMINALS MARKED WITH PAINT SPOTS COLOURED THE SAME AS THE LEADS.

THIS DIAGRAM FOR SERIALS Nos 604 & UP

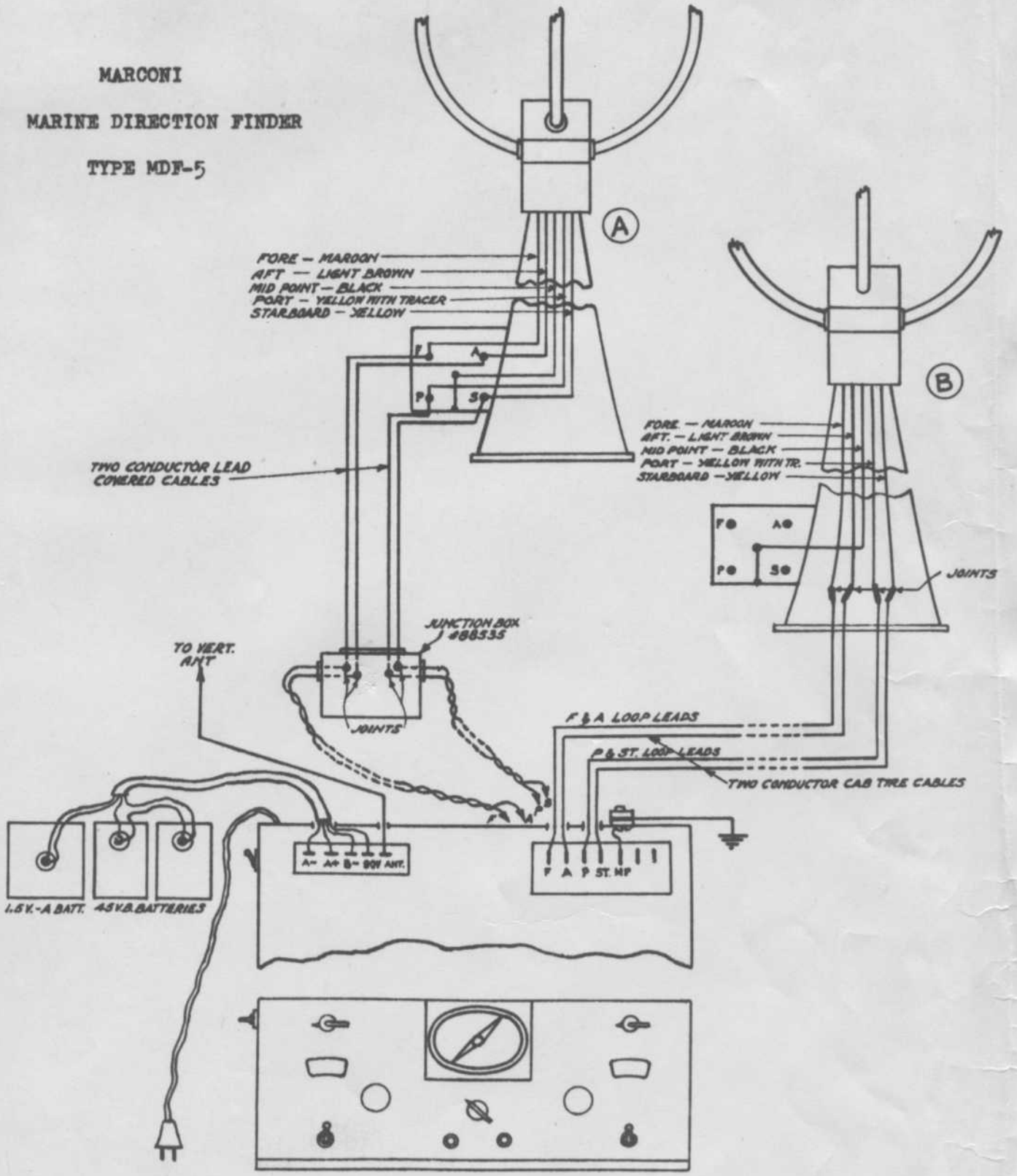
DIAGRAM OF CONNECTIONS

HUGH LOUIS E.R.

MARCONI

MARINE DIRECTION FINDER

TYPE MDF-5



(A) FOR LEAD COVERED PAPER INSULATED CABLES

(B) FOR CAB TIRE CABLES.

INTER-UNIT CONNECTIONS
RECEIVER TO LOOP – M.D.F-5