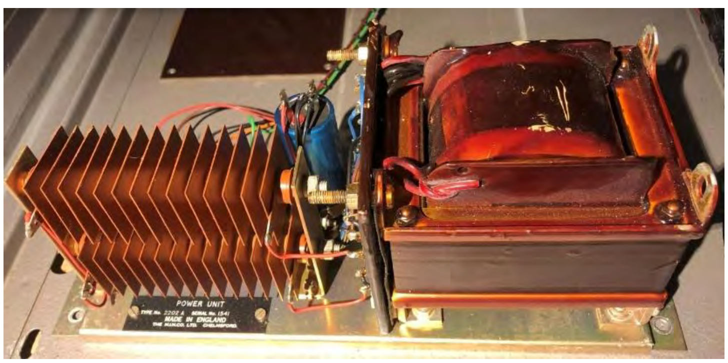
Refurbishing a 'Forgotten' Marconi Atalanta Marine Receiver – Gerry O'Hara

Around five years ago, a friend asked me to check out a Marconi 'Atalanta' marine receiver he had owned for some time (photo, right). He had noted that it was working, but wanted some assurance 'all was well' and, if any preventative maintenance was needed, to carry it out. That receiver was almost immaculate, inside and out, and was fitted with an internal mains power supply[1]. I recall that I replaced the electrolytic capacitors, a few 'must do' tubular paper capacitors, eg. audio coupling capacitors, and a few resistors, as well as replacing the large selenium rectifier in the power supply (photo, left) with a silicon rectifier, and cleaning switches, tuning gang, etc., but otherwise I 'left well alone', as the receiver was performing well.



Fast-forward five years, and during a 'phone chat one evening, the same friend noted that he had stumbled across another Atalanta receiver in his (very large) collection of communications receivers (photo, below) – it had become "*buried under other stuff*" over the years. He also mentioned that he had never used this one as it did not have an internal power supply[2], but after rediscovering it had decided that he would like to have it refurbished and an (external) power supply

[1] Indicating that it was likely used in a marine shore station

[2] The Atalanta requires a 110vDC 0.45A power supply – this feeds both the B+ and (series connected) tube heaters

built for it. He asked if I was interested in taking on the task of checking-out and refurbishing this 'forgotten' Atalanta, and to build a power supply for it – and, of course, I said 'yes'!

In a later 'phone conversation, my friend commented that he had some 'industrial' power transformers that had a 60vAC 5A secondary winding, and that he would like to use one of these with a voltage doubler rectifier arrangement to power the Atalanta – I suggested that if this was done, then a Variac should be included so that the output voltage could be adjusted to the required 110vDC. My friend subsequently partly constructed the power supply on a 'breadboard' (transformer, Variac, switch, fuseholder, capacitors and lamp) – photo, right, and provided this, plus the rectifiers, with the Atalanta.

The Marconi 'Atalanta'

The (UK) Marconi company introduced two new receivers for the marine market in 1953 – the Model 1017 ('Mercury' – photo, right, top) and Model 1018 ('Electra'[3] – photo, right, bottom). The Mercury covered 15KHz – 40KHz, and 100KHz – 4MHz, and the Electra covered 25KHz – 520KHz, and 1.5MHz – 25MHz, including a mechanical bandspread for the marine bands. The Mercury, with its limited frequency coverage, was designed specifically for the marine market, and was usually paired with the Electra on shipboard installations, as shown in the photo, right[4], to increase the frequency range of the station to cover the HF marine bands. In 1958, Marconi introduced the similar-looking Model 2207C ('Atalanta' – photos, page 1), that provided a single main receiver solution for shipboard and marine shore station use, with continuous coverage from 15KHz – 28MHz, also with mechanical bandspread for six marine bands, combined with using more modern tube types and an overall improved technical specification. The Atalanta stayed in production until 1967[5] and

[3] Not to be confused with the 'Elettra' (Marconi Model 8870A), which was a re-badged solid-state Eddystone Model EB35 ('Elettra' was also the name of Marconi's steam yacht)

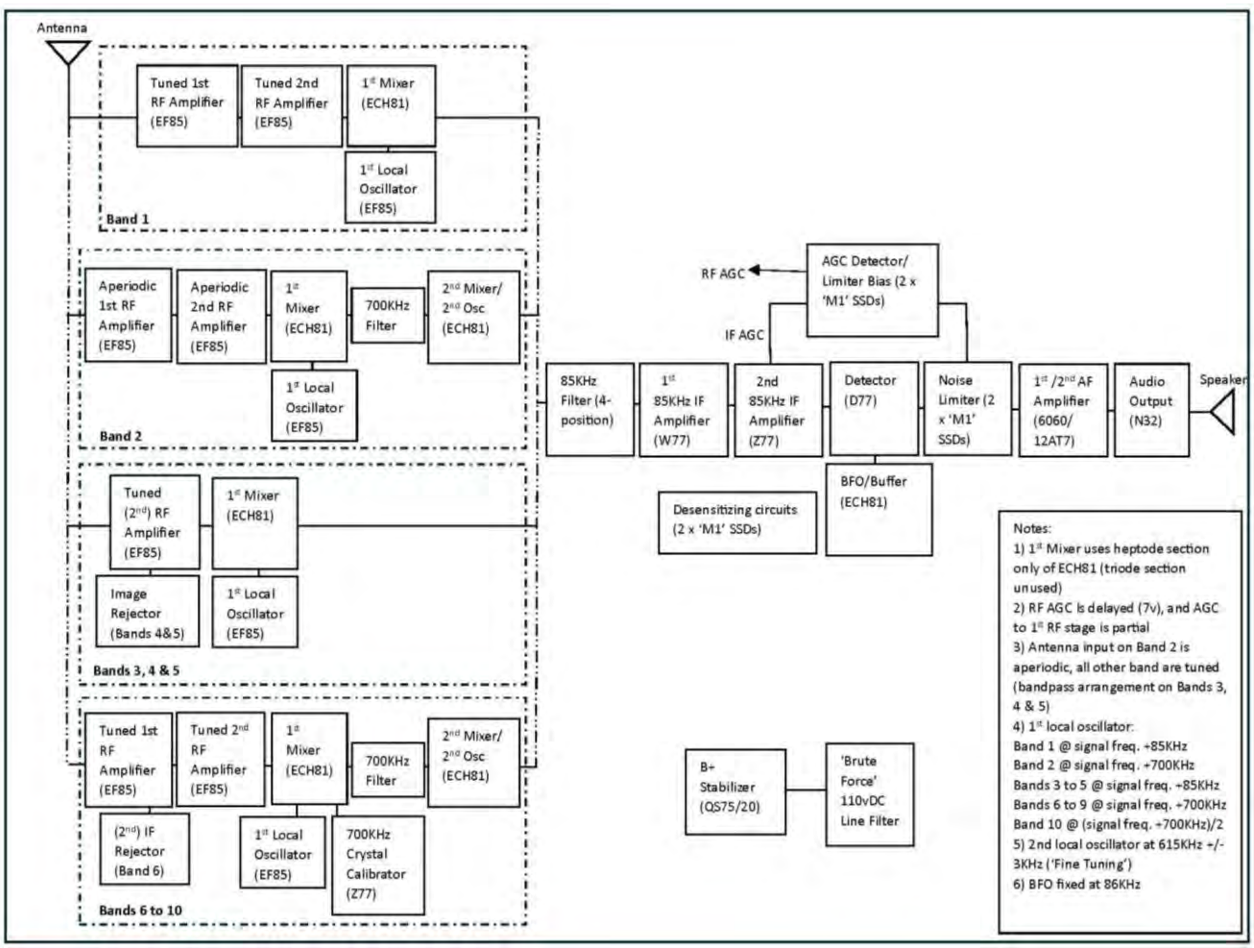
[4] Photo courtesy of Jerry Proc

[5] This chassis is S/N 3336, and the latest date on an electrolytic capacitor in the chassis was April, 1965

was an extremely reliable and high performing receiver, becoming a 'stalwart' primary ('main') radio of British and Commonwealth ships for many years. Even so, few of these radios were sold in the surplus market after decommissioning (reportedly scrapped by Marconi at end of lease), and hence they are classified as 'Extremely Scarce'[6]. Competitors to the Atalanta included International Marine Radio (IMR) and Redifon products, such as the R146 and the later (solid-state) R408, and continental models such as the Siemens E-310. The Atalanta was superseded by the solid state Apollo, which catered for SSB use, whereas the Atalanta and its competitors were designed as AM/MCW and CW only receivers.

Circuit

The Atalanta is a conventional dual-conversion superhet tube radio, designed specifically as a main receiver onboard marine vessels or shore stations. The design allows for continuous coverage from VLF (15KHz) through to 28MHz in ten bands, with mechanical bandspread for six marine bands. It employs thirteen tubes[7] and six small signal (single plate) selenium rectifiers. The topology of the front end of the receiver changes between bands to accommodate the continuous coverage across the wide range of frequencies, as illustrated in the simplified block diagram below. Full block diagrams for each of the four topologies are provided in the Appendix, along with the schematic.



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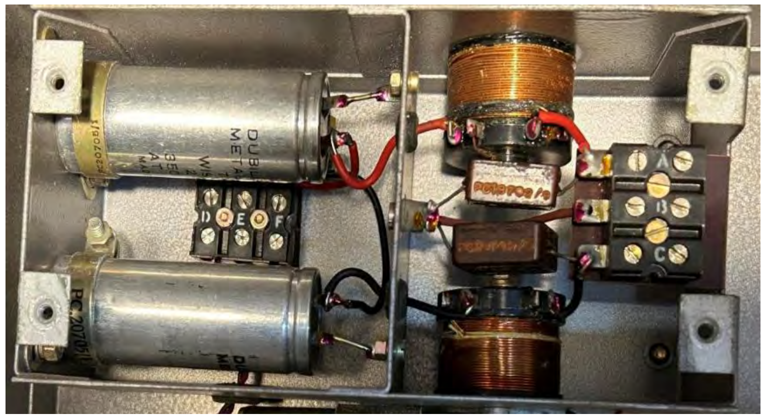
[6] Shortwave Receivers Past & Present (Communications Receivers 1942 – 2013), 4th Ed., 2014, Fred Osterman

[7] Fourteen tubes if the optional muting circuit using an ECH81 tube was installed. The chassis includes cut-outs for this tube and a relay

The circuit comprises two stages of RF amplification (2 x EF85[8]), 1st mixer (heptode section of an ECH81), 1st local oscillator (EF85), 2nd mixer and 2nd local oscillator (ECH81), 1st IF amplifier (W77), 2nd IF amplifier (Z77), detector (D77/EB91), BFO (ECH81/X719), AF amplifier (6060/B309/12AT7), AF output (N37), 700KHz crystal calibrator oscillator (Z77), and voltage stabilizer (QS75/20). The chassis could be fitted with an optional muting circuit (ECH81/X719). The chassis requires 110vDC at around 0.45A to operate, this supplying both the B+ and also the tube heaters/dial bulbs, these being in series configuration[9]. Provision is made to provide this voltage from a variety of sources, including an optional internal power supply operating from 115/230vAC[10], mounted in the rear of the cabinet, or external supplies, eg. directly from the ships 110vDC or 220vDC[11] bus, or from external power supplies, including for 24vDC operation[12]. A 'brute force' L-C RFI filter is included in the rear of the cabinet (photo, right), together with terminal blocks to connect to muting and desensitizing circuits when used with a transmitter.



The 2nd IF is at 85KHz, used on all bands, and the 1st IF is 700KHz, used on Bands 2, and 6 through 10. On Bands 3, 4, and 5, the 1st RF stage is out of circuit, and the secondary windings of the antenna transformers are coupled to the primary windings of the RF interstage transformers forming a tuned bandpass filter. An IF rejection circuit ('trap') is provided for 700KHz on Band 6[13], and image rejection circuits are included for 950KHz on Band 5, and 550KHz on Band 4[14] to maintain the image rejection specification of the receiver at these frequencies (>85dB). The single frequency conversion technique used for Bands 1, 3, 4 and 5 with an IF of 85KHz cannot be used on Band 2 as this band covers 85KHz, necessitating the use of double conversion on this band, as used on Bands 6 through 10. This requirement would result in tracking difficulties for the RF tuned circuits as the required signal frequency change would be more than three times the corresponding (1st) local oscillator frequency change[15]. To overcome this, the signal frequency circuits on this band are aperiodic, comprising an untuned transformer input with high and low-pass filters, providing a broadband circuit covering the entire 25kHz to 100KHz span of Band 2, with frequency selection provided only by tuning of the 1st local oscillator[16].

On Band 10, the 2nd harmonic of the 1st local oscillator is used so that the maximum frequency of the oscillator is around 14.5MHz instead of around 29MHz in order to improve frequency stability on this

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[8] The choice of EF85 tubes is interesting: being a 'VHF' tube it was reportedly slightly quieter than tubes designed for HF use. Also, the EF85 offered a variable-mu RF pentode with a 300mA filament that provided a reasonable slope at low plate voltages, as in the Atalanta design

[9] The heater string used 300mA filament tubes, however, it did include one 200 mA filament tube (which thus required a heater shunt resistor) namely the W77 1st 85KHz IF amplifier

[10] Marconi Type 2202A (photo, page 1)

[11] Using a 'resistor unit' – Berco Type UGHK5/SA69

[12] Marconi Type 2203A

[13] The lowest frequency on this band is 800KHz - close to the 700kHz IF, and this could enter the 700KHz IF string along with the wanted signal

[14] The image rejector circuits give maximum rejection at 780KHz (950KHz – 2x85KHz) on Band 5, and 380KHz (550KHz – 2x85KHz) on Band 4

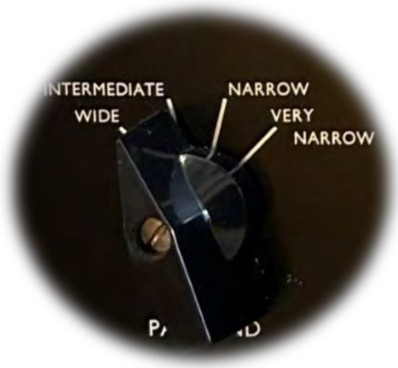
[15] With L-C filtering, a very difficult 16:1 capacitance ratio would be necessary here

[16] Although not ideal, in practice, this workaround works reasonably well for this limited range of frequencies

band. Also, a separate tube is used for the 1st local oscillator instead of using the triode section of the ECH81 used as the 1st mixer, to improve the signal to noise ratio and frequency stability. An adjustable bi-metal temperature compensation capacitor is also included to improve long-term frequency stability.

The frequency of the 2nd local oscillator is fixed at 615KHz, but provision is made to adjust this frequency slightly (+/-3kHz) using a 'Fine Tuning' control on the front panel. The bandwidth of the 1st IF (700KHz) is kept wide enough for the gain of the receiver not to be effected over this 6KHz span[17].

Four selectivity positions are provided: 'Wide' (8KHz), 'Intermediate' (3KHz), 'Narrow' (1KHz), and 'Very Narrow' (100Hz)[18]. The Wide, Intermediate and Narrow bandwidths are effected by varying the coupling between the primary and secondary windings of the 85KHz IF transformers. For the Very Narrow position, a 'magnetorestrictive' filter is switched into circuit[19].



A balanced detector circuit is used for CW reception, this having the advantages of eliminating unwanted voice/MCW interference on adjacent frequencies, and any beat frequencies originating from unwanted carriers. For phone/MCW reception, one of the detector diodes is disabled.

The manual RF gain control comprises a dual pot: the first having an inverse-log taper, which controls the bias on the two RF amplifier stages, the second having a log taper, this controlling the bias on the 1st 85KHz IF amplifier stage[20]. This arrangement reduces the IF stage gain faster than the RF stages gain, thus maximising the signal to noise ratio, as well as mitigating cross-modulation and 'blocking' at various RF gain settings. Two AGC circuits are used: the first provides direct AGC to the 1st 85KHz IF amplifier stage (no AGC is applied to the 2nd 85KHz IF amplifier stage), this voltage also providing bias to the automatic dual (selenium) diode series noise limiter circuit. The second provides delayed AGC to the two RF amplifier stages, the 1st RF amplifier stage AGC voltage being partial – the delay and reduced AGC voltage to these stages provides higher gain in these stages during reception of low-level signals to maximize the signal to noise ratio. The AGC voltages are derived from two (selenium) diodes, these being fed the IF signal from plate circuit of the 2nd 85KHz IF amplifier.

The BFO is a fixed frequency oscillator, tuned to 86KHz, providing a nominal 1kHz beat note when a CW signal is tuned 'on the nose'[21]. The output of the BFO is fed to the centre tap of the secondary winding of the final 85KHz IF transformer.

The audio stages include high and low frequency filtering to reduce unwanted noise/hum, and to stabilize the receiver when tuned to very low RF frequencies, these being in the audio frequency part of the spectrum. Provision is made for a sidetone input from a transmitter, and for output to

[17] Having -6dB bandwidths of 14KHz when 'Wide' and 'Intermediate' selectivity positions are selected, and 8KHz in the 'Narrow' and 'Very Narrow' selectivity positions

[18] Bandwidths are for -6dB

[19] See Appendix for description of a magnetorestrictive filter

[20] 'RV2' (inverse-log) pot is at the rear, and 'RV3' (log) pot at front of the dual pot assembly

[21] This is a limitation for SSB reception (the Atalanta was not designed for SSB), as there is no provision to change the BFO frequency to 84KHz for reception of the other sideband. There is a 'spare' position on the front panel 'System' (mode or function) switch that can apparently be used in a modification to provide such switching of the BFO frequency, though I have not tried this (also see final comment in this thread)

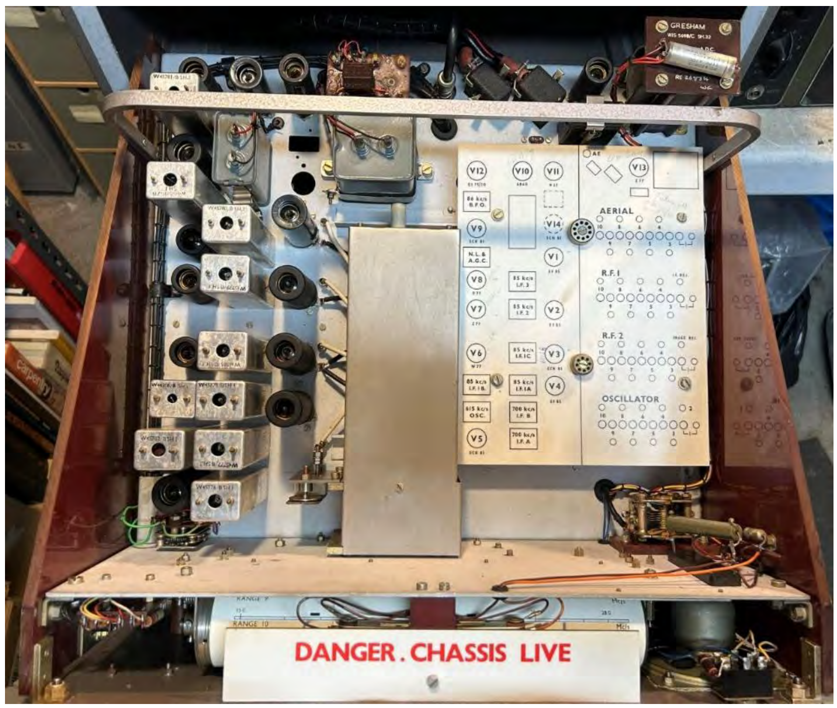
internal/external speakers, plus two 'phone jacks. An optional muting circuit may be fitted to the chassis, this designed to silence the receiver while monitoring a frequency in the absence of a signal.

When used with a transmitter, provision is made for either cathode or grid desensitizing techniques. If the former technique is used, a link must be removed on the top of the receiver chassis to allow the 1st 85KHz IF tube to be biased off during transmission, and the telegraphy key used must have a 'back' (key-up) contact. The chassis includes two relays for use if a 24vDC supply is available to power their solenoids, one disconnecting the antenna and the other biasing the RF and 1st 85KHz amplifier tubes off. If the latter desensitizing technique is used, a negative voltage, derived from the (tube) transmitter final stage grid, is used to override the AGC voltage of the receiver.

Mechanical Construction

The Atalanta is built on a stout plated steel chassis, with even stouter phenolic ('Paxolin') side panels (photos, right and below). Being a 'live chassis' design, the insulated side panels and other provisions for insulating the cabinet and front panel/controls and 'phones jacks is necessary for safety, and a prominent 'DANGER. LIVE CHASSIS' notice is attached to the rear of the front panel as a warning to anyone removing the chassis from the cabinet[22].

The RF deck is located on the right, and IF/audio circuits on the left (viewed from the front).

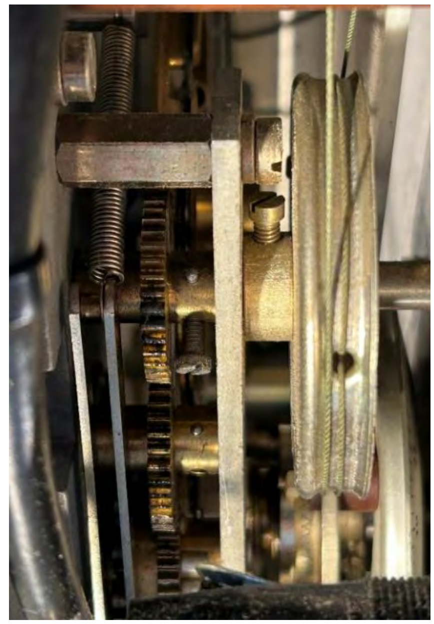


A transverse 'roll bar' is provided close to the rear of the chassis to avoid damage to components above the chassis when inverted for servicing – a nice touch. The tuning gang is fully enclosed with a removable cover, and the trimmers/slugs on the RF deck are covered by a removable plastic sheet that has the locations of the trimmers/slugs, IF transformers and other above chassis components marked on it - another nice touch. The RF amplifier stages, mixer stage and 1st local oscillator

[22] Use of an isolation transformer is essential when working on such 'live chassis' devices, both for safety and for protection of any instruments connected to it when being serviced

tuned circuit components are in screened compartments, with the tubes for these stages mounted in the same compartment as the IF, detector, BFO and audio stages, though having shielding covers over the tube sockets.

Most passive components are mounted on (12) tag boards, facilitating servicing, however, some resistors and capacitors are inevitably mounted on tube sockets, on switch wafers, and between RF transformer terminals, etc., as well as inside the BFO coil housing and the ‘AGC/NL’ can, the latter also including two (selenium) rectifiers. Surprisingly, for a receiver of this quality and ‘heavy-duty’ construction designed for 24/7 use aboard ships, ceramic switch wafers are not used in the band change switch (or other rotary switches), these all having phenolic wafers, albeit of high quality, robust construction.



The tuning control is coupled to the tuning gang via a robust gearbox arrangement, with stout brass gear and pinions (photo, right), which includes a number of designated oiling locations. Rotation of the main tuning dial drum and pointer, as well as the bandspread tuning pointer are effected using dial cords and pulleys (see Appendix). The tuning mechanism is remarkably smooth and positive in action, and the large, weighted, tuning knob includes finger recesses on its front surface that allows for rapid, flywheel-enhanced traverse of each band. The gearbox includes a push-in/pull-out bandspread tuning scale engagement mechanism that also has a reassuring, very positive feel.

Controls

The front panel controls (photo, right), comprise AGC/Noise Limiter, AF Gain, Passband (selectivity), Range (band), Tuning, Bandspread Tuning (labelled “Push in for Bandspread”), System (mode/function), RF Gain, Fine Tuning, and Mains On/Off (toggle). Two (‘mains’) fuses and two ‘phones sockets are also provided on the front panel. Many Atalanta receivers, including this one, were fitted with a small internal speaker and a toggle switch to mute this when an external speaker/’phones were used. The main tuning dial is a rotating drum with a movable pointer. A logging scale, strangely marked 0 to 40, is engraved on the fingerplate below the scale window. Mechanical bandspread is provided for six marine bands, these being marked as 4.1 – 4.4MHz, 6.1 – 6.7MHz, 8.2 – 8.8MHz, 12.2 – 13.3MHz, 16.4 – 17.6MHz, and 21.8 – 23MHz, each having some 'overshoot' allowance at either end of the scales beyond the marked frequencies. The bandspread tuning is engaged by pushing in the relevant knob on the front panel. The method of using the bandspread is described in a video, here.

There are no controls or other facilities on the rear of the receiver, and connections to the power supply and any connections to a transmitter, eg. for desensitizing, are via flying leads that enter the cabinet through a louvre at the base of the rear of the cabinet. The antenna connection is via a 'Belling-Lee' socket mounted on the right side of the cabinet. The 'mains' filter and terminal blocks to connect to receiver circuits are mounted on the inside of the rear cabinet panel, these connecting to the chassis via two umbilical cables fitted with Jones plugs (photo, right). The umbilical cables and the coax cable are sufficiently long to allow the chassis to be connected outside the cabinet for servicing. The 'Belling-Lee' antenna socket connects to the receiver via a coax cable fitted with a 'Belling-Lee' plug at the receiver end, this mating with a second 'Belling-Lee' socket on the chassis (to the left of the Jones plugs in the photo, above), the shield of the coax cable being isolated from the ('live') chassis at DC, but coupled at RF via a capacitor.

Three 12-pin Jones sockets, termed 'E', 'F' and 'G' are provided for 'Feed Metering'[23] during servicing. These sockets are located on one of the chassis side panels (photo, bottom of page 2).

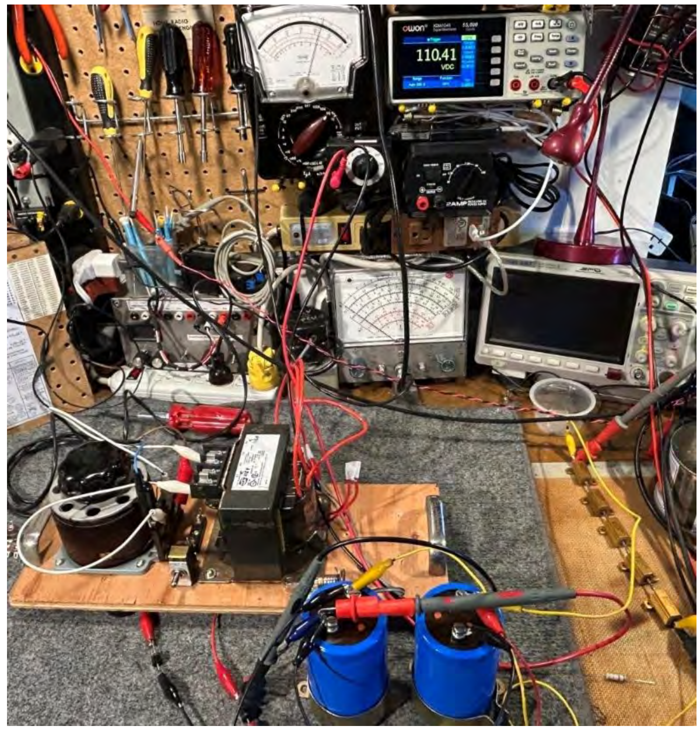
Power Supply

Prior to working on the receiver, I thought it prudent to first complete construction and testing of the (somewhat unusual) power supply. As noted in the preamble, the owner of the Atalanta had part-constructed this supply using a 60v secondary power transformer he had in his 'junk box', plus a number of other parts mounted on a plywood breadboard (photo, page 2). His intention was to use a voltage doubler circuit to provide the 110vDC needed for the Atalanta supply, and, at my suggestion, with fine-tuning of the output voltage via a Variac in the primary circuit of the power transformer. The parts mounted on the breadboard included a couple of large can capacitors, both 425uF 450vw that tested very good with an ESR of 0.08, that he told me were there as 'props' or 'placeholders' for some larger value capacitors that he had ordered[24].

[23] These sockets are wired to critical circuit nodes to aid in diagnostics by connecting to an external test jig using an AVO Model 8 VOM to measure voltages. A 'Feed Metering' table is provided in the Atalanta manual (Table 4, page 25/26)

[24] The new (2,000uF 450vw) capacitors were too large for the clamps on the breadboard, so the owner also ordered a couple of suitably-sized clamps, which fitted perfectly

I first jury-rigged the voltage doubler power supply for the Marconi Atalanta using the new 2000uF 450vw electrolytics and the two '10A10 MIC' rectifiers the owner supplied (10A 1000PIV rated, with a 600A surge capability). I used a full-wave voltage doubler circuit, which according to the spec. of the transformer, should be able to provide up to 5.77A - that's serious current at 110vDC, and the supply will provide much higher voltage than that if the Variac is wound up to maximum (over 150vDC).



Next, I tested the circuit with a 10Kohm 2W resistor as the load - all seemed to work ok, so I strung together five metal-clad 50ohm 25W resistors in series to provide a 250ohm 125W load (though without being bolted to a heatsink, probably more like 60W) – these resistors can be seen at the right side of the photo, right. This would draw around 440mA - a reasonable representation of the current draw of the Atalanta receiver (300mA heater string plus an estimated around 130mA B+ current draw).

I found that an input voltage of around 45vAC to the voltage doubler gave an output voltage of 110vDC with the 440mA load connected. I left this arrangement running for around twenty minutes and took some thermal images - the power supply components were all running fairly cool, but the power resistors forming the dummy load were getting a bit 'toasty', so I switched things off. Before I did so, I checked the ripple voltage on the output of the power supply (across the dummy load) using a Tektronix 465B 'scope fitted with a x100 probe. The ripple voltage measured around 270mV p-p (around 95mV RMS), equating to around 0.1% on the 110vDC supply, which I figured should be ok (the power supply on board ships was notoriously 'rough' and noisy), though if not, additional (L-C) smoothing is present in both the receiver cabinet and on the chassis.

Satisfied that the power supply design was up to the job, I kept the construction simple using as many of the components the owner supplied as possible (all but one); comments as follows:

- I found that one half of the DPST switch the owner supplied was always on, but the other half was working ok, so I still used it;

- I wired the (5W 120v) indicator bulb the owner supplied across the output. It draws around 60mA at 110vDC, so acts as a good bleed resistor, as well as indicating that the power supply is switched on and that DC is present on the output. I left sufficient wire on the bulbholder that it could easily be re-wired to the AC input after the switch if the owner prefers;

- I replaced the single fuseholder with a double one: one half is used for the line and the other half the DC output to protect against shorts on the leads to the receiver and in the 'brute force' filter (the receiver circuits are protected by two fuses on the chassis). I installed a 2A slow blow fuse cartridge in the line fuseholder and a 0.75A slow blow fuse cartridge in the DC fuseholder;

- I wired the Variac to provide the lowest output voltage range, providing the best adjustment range to obtain 110vDC output. This can still adjust the DC output voltage up to around 150vDC (the higher voltage tap gives up to 175vDC output). I used ring terminals for the connections to the Variac so the voltage range can be changed easily if the owner ever wants to;

- The transformer 60vAC secondary centre tap and the wires to a 20vAC secondary were insulated with heat shrink;

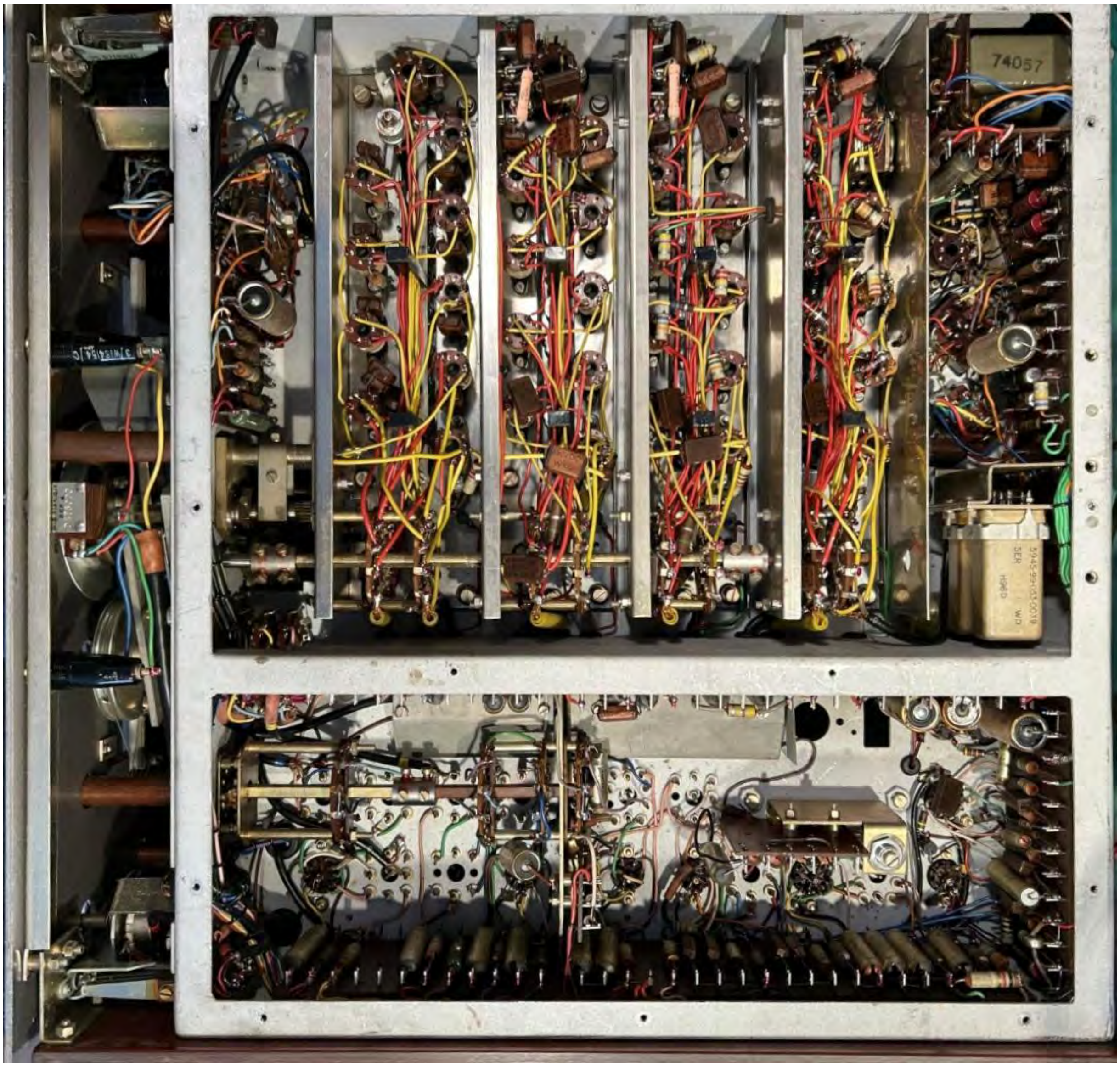
- There are a lot of exposed terminals with high voltage on them (up to 114vAC and 150vDC), so some effort was needed to prevent accidental contact (the owner has no kids or pets, but still....!); and

- I used a polarized line cord with no ground connection due to the breadboard construction – the receiver cabinet to be grounded separately using the station grounding arrangements.

With the indicator bulb drawing 60mA at 110VDC, adding the 250ohm power resistor string across the output without adjusting the Variac dropped the voltage to around 100vDC. If the output voltage was adjusted to 110vDC with the 440mA resistor load attached, the output voltage rose to 122vDC when the load was disconnected. I concluded that this poor regulation should not matter in practice, as the voltage could easily be re-adjusted to 110vDC with a slight turn of the Variac control, and the Atalanta will draw a fairly steady current once warmed-up. With around 500mA output current draw at 110vDC, the supply was drawing around 70W at 117vAC, and all components were running cool. I noted to the owner that it would be useful to add a DVM onto the breadboard for convenience when adjusting the Variac, and that the power supply would be better if built into an enclosure if he had anything suitable (the owner is capable of doing that build). In the meantime, I added a sheet of clear plastic as a guard over the high voltage parts of the power supply (photo, right) - a bit crude, but did the job, at least as a temporary measure. The on-off switch could be operated by curling a finger around the end of the guard, though the guard would need to be lifted off to change a fuse (four screws and it lifts away). I also added a connection block to the output, and wired-in a 2-pin in-line Jones socket on a short 'pigtail' wire ready for when it was time to test it with the receiver.

Initial Inspection of the Atalanta

I first asked the owner if he had any ideas in mind as to what he would like me to do regarding refurbishment, or if he would like me to provide an opinion once I had given the chassis a 'once-over' first? He opted for the latter, and also noted that originality under the chassis was not a concern, but that the above-chassis appearance should be 'factory'. So I proceeded with the inspection with that in mind.

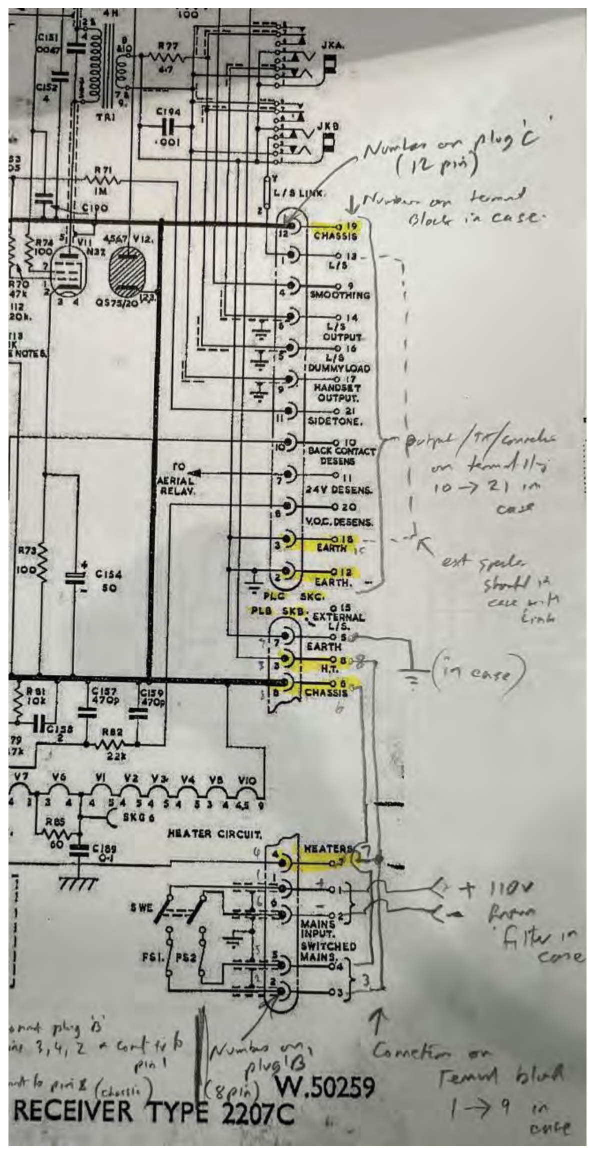


Above the chassis, all looked to be in good shape (photo, page 6), however, I noted that the 8uF metal clad paper 'block' B+ smoothing capacitor was a little loose in its clamp, as the layer of foam between the capacitor and the clamp was degrading to dust (photo, right), however, this was not of great concern.

On first glance, none of the 'TTC' manufactured tubular 'Metalmite' metal-clad paper capacitors or electrolytic capacitor seals underneath the chassis (photo, above) appeared to be cracked or seeping fluid, so that was good sign… so, given my experience with these chassis in the past, I asked the owner if he would like me to try powering it up after some continuity/resistance and safety checks. The owner decided to throw caution to the wind (well, almost), and agreed for me to do this after I was satisfied there were no 'show-stoppers' resulting from my visual inspection and resistance checks on the receiver chassis. I found no issues that suggested there could be a problem, so I prepared things for an initial power-on test.

Initial Power-on Test

First, I checked out the wiring in the Atalanta cabinet - there were a couple of wires loose that should have been connected to the smaller of the two terminal blocks. I took a little time to check the schematics before I was happy everything was connected ok. I then wired up the 2-pin in-line Jones plug to a length of twisted wire pair, and wired the other end into the input of the 'brute force' filter in the Atalanta cabinet. However, with the cabinet and the receiver chassis both on the bench, I found I could not maneuver them together such that I could insert the two Jones plugs and 'Belling Lee' (coax) antenna plug into place with their short(ish) 'flying leads' and still have adequate access to the receiver chassis (and for myself!). So, I decided to move the cabinet off the bench and make up a temporary lead to connect the power supply direct to the chassis.

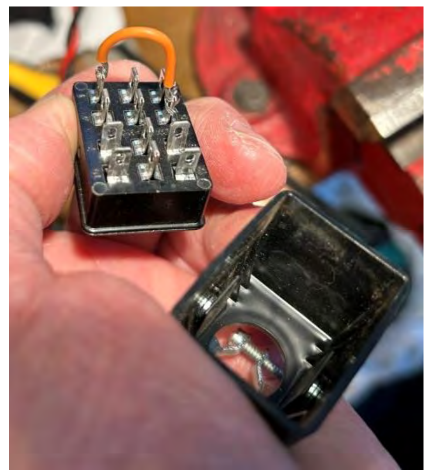


To do this, I simply wired an 8-pin in-line Jones socket (actually a chassis socket as I could not find a proper in-line socket - good enough for testing) onto the other end of the twisted wire pair that had the 2-pin Jones plug on the other end. The 8-pin Jones socket mates with an 8-pin Jones plug on the chassis that provides power supply and on/off switching. To mimic enough of the wiring in the cabinet to render the receiver operational, I wired pins 2, 3,and 4 of the Jones socket together, then the +ve 110vDC supply wire to pin 1 and the -ve (chassis ground) wire to pin 8 (part schematic, right). This allowed one side of the power switch on the receiver front panel to switch the receiver on/off, and for the 'hot' end of the (110vDC) series heater string and the receiver B+ line to be coupled together.

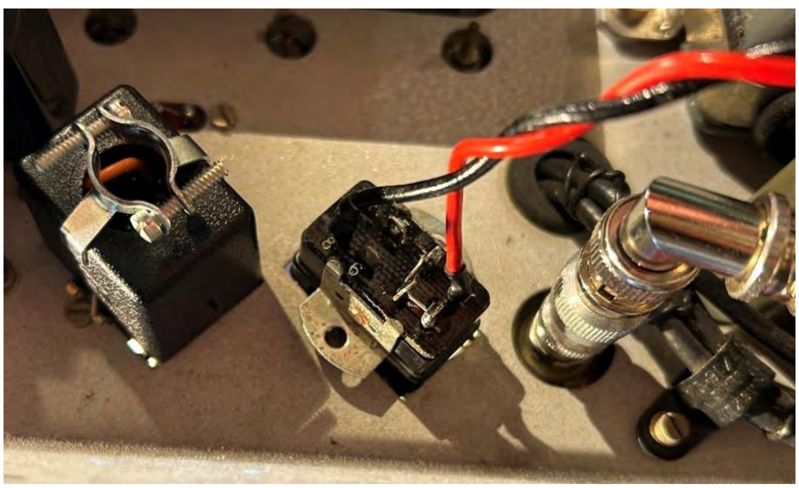
I then applied around 25vDC to the receiver (using the Variac on the breadboard power supply), increasing this to 110vDC (105vDC B+ after the 7H input filter choke on the receiver chassis), in 5v increments over around 30 mins to, hoping to re-form the electrolytic capacitors. While doing this, I monitored the current draw using a clamp-on meter. At 110vDC, the current draw was around 425mA - very close to my estimate based on the 300mA series heater string and around 130mA B+ current draw. This indicated that there were likely no capacitors leaking excessively or resistors too far out of kilter.

Speaker Issue

So, all good? - no, there was complete silence from the internal speaker! Throwing the speaker toggle switch a few times made no difference, so I connected an external speaker to the second chassis-mounted Jones plug (a 12-pin one) - this Jones plug provides ancillary connections to a transmitter, eg. for de-sensitizing and sidetone, external speaker, etc. Pin 1 of this plug is the speaker connection (the other speaker connection is to chassis ground). The result? - silence from an external speaker also. So, I plugged in some 'phones, and Yeah! - the receiver was working, pulling in Broadcast band and WWV on shortwaves. I left the chassis running for around an hour and took some thermal images of the chassis - as far as I could tell, only the wire-wound power resistors and higher-wattage carbon composition resistors were the hot spots – all good news. All controls appeared to be working as they should, though some switches and controls were noisy and needed some cleaning.

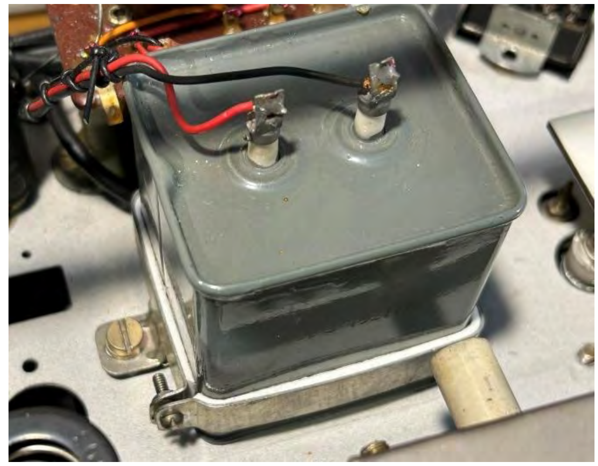


After some thought and checking the schematic (page 12 and Appendix), I resolved the non-working speaker problem - there were actually two problems: the first was that two of the terminal block connections in the cabinet ('13' and '14') must be connected together for the internal speaker to be connected - without the cabinet, of course these were not(!). These terminals correspond to pins 1 and 6 of the 12-pin chassis-mounted Jones plug. I found a 12-pin socket in my junk box, connected pins 1 and 6 (photo, right), installed it on the chassis socket (photo, below), and.... still silence(!). The second issue was tarnished contacts in the switching 'phones sockets - these needed burnishing and cleaning with Deoxit D5. After that, the internal speaker was finally working. A short video demo of the receiver working at this stage can be viewed here.



I then cleaned all the rotary switch contacts with Deoxit D5-soaked Q-tips (or a light spray of Deoxit D5 where a Q-tip would not go). I then confirmed that the receiver was working on all bands, at least from 100KHz upwards - it did. I noted that the calibrator was not working too well, so that would need investigation.

Although the receiver appeared to be generally working, the owner asked me to replace whatever was needed/should be replaced to improve its longer-term reliability and/or performance. This would likely include the electrolytics, some coupling and bypass capacitors, and any resistors that had drifted sufficiently out of tolerance to significantly impact performance.



At this stage, the 8uF block paper B+ filter capacitor was starting to annoy me: as I moved the chassis about, pieces of the foam were falling on the bench, and the capacitor was becoming looser as result. So, I removed the capacitor (and clamp) from the chassis, scraped the remaining foam off the capacitor body and the clamp, placed some new adhesive foam strip around the inside of the clamp and re-installed the capacitor onto the chassis (photo, right) – now solid as a rock.

Tubes

I then removed and tested the tubes. Those fitted to this chassis were quality ones from Amperex, Telefunken and Marconi (some of these could be the original tubes) – photos, right. All tubes I tested were in good shape, with Gms at the higher end of the typical range. I could not test one tube: the output tube is an 'N37', a 1950's TV tube with a 13v heater, but it was working ok as far as I could tell.

Voltage Measurements

With the tubes re-installed, I then measured voltages on each pin of every tube socket in the chassis, and comparing them with the voltage table in the Atalanta manual (Table 3, page 24).

The acceptable tolerance noted in the manual when measuring with a 20,000ohms/volt meter is +/-10%, except for the voltage stabilizer tube, which is noted as +/-5%, and the heater voltages. The latter are noted as 'nominal', as the heaters are in series configuration and it is recommended that the actual voltages across each of the tube heater connections is measured, which should be 6.3v for all tubes except the output tube (N37) which should be 13v (all +/-10%), and, of course, the voltage stabilizer tube (no heater!). I noted some mistakes in the voltage table, eg. the stabilized voltage tube voltage is given as 70v (it should be 75v), and I also suspect that the 'condition' of one set of readings which notes 'A.F. gain anti-clockwise' should be 'R.F. gain anti-clockwise', as the position of the AF gain control would not affect DC voltages in the RF and IF stages.

I took the voltage measurements with a Triplett 630N VOM (20,000ohms/volt), and several measurements were outside the +/-10% tolerance. Of note, was that almost all the heater voltages were significantly 'off' their nominal values - all low, some by over 20%. The lowest of the 6.3v heater tubes was for V9 at 4.9v, and V11, the 13v heater output tube (N37), measured only 10.9v. About another 12 measurements were outside the +/-10% tolerance, and some noted as '0'v in the voltage table measured a small negative voltage. As all the tubes tested ok, I suspected that the off-spec. voltages were likely due to resistors drifting out of tolerance and/or leaky capacitors.

Tube Heater String Troubleshooting

My first line of investigation was to check the heater string. I did a few calculations and surmised that there was likely a problem with the two Brimar 'CZ2' thermistors (in parallel) that feed the tube heater string in parallel with a 330ohm 10W resistor. I went looking for the thermistors and found that they had been replaced by two 270ohm 3W(?) resistors – photo, right. This would explain the low heater voltages, as the voltage drop of these three resistors in parallel with 300mA current draw through the heater string would be 29v. Subtracting this from the 110v supply voltage and allowing around 8v loss for the two (4v) dial lights and the CZ9 thermistor in parallel with them (this thermistor becomes effective if one of the bulbs fails, allowing the set to continue operating), would result in around 73v at the 'hot' end of the heater string (I had actually measured 76v). Replacing thermistors with resistors would also explain why the two dial lights glowed very brightly on switch-on.

SUMMARY OF CHARACTERISTICS

Type	Dimensions (inches)	Initial Resistance Ohms 0°C	Initial Resistance Ohms 20°C	Initial Resistance Ohms 50°C	Max. Voltage Factor "k"	E_{max} Volts 20°C	Max. Operating Current Amp.	Resistance* at Max. Operating Current Ohms	Max. Instantaneous Current Amp.
CZ1 CZ1A	1¼ × 5/16	8 300	3 800	1 400	2.36	25	0.3	44	0.6
CZ2	7/8 × ¼	12 500	5 500	1 850	2.47	30	0.3	38	0.4

CZ2 thermistors have a nominal 'cold' resistance (room temperature, 20C) of around 5Kohms (table, left), and a resistance at full current (300mA max) of 38ohms, so two in parallel would have a minimum 'hot' resistance of around 19ohms. However, in this circuit, each thermistor would only carry around 125mA (the 330ohm resistor in parallel with them carrying around 50mA once they reached operating temperature), so would have a higher resistance at their working temperature, estimated from the CZ2 resistance v. current chart at around 100ohms each. This would, when in parallel with the 330ohms power resistor give an effective resistance when hot of around 44ohms, resulting in a 13v drop. Subtracting this from the 110v supply voltage and allowing around 8v for loss across the two 4v dial lights (in series) and the Brimar 'CZ9' thermistor in parallel with them, would result in around 89v at the 'hot' end of the heater string (the manual specifies this as 88.6v +/-10%).

I checked my junk box and found a few NOS Brimar CZ1 thermistors donated to me a few years ago by a generous fellow vintage radio guy in Australia for use in an Eddystone AC/DC set I was working on.

These thermistors are a little larger physically than the CZ2, but have a similar characteristic resistance v. current curve, and a higher maximum instantaneous surge current. At 125mA, their resistance is quoted at around 110ohms. With two of these in parallel with the 330ohm power resistor, this would give a 14v drop. Subtracting this from the 110vDC supply voltage, and allowing around 8v for loss across the two 4v dial lights (in series) and the Brimar 'CZ9' thermistor in parallel with them, would result in around 88v at the 'hot' end of the tube heater string (the manual specifies this as 88.6v +/-10%). Note: thermistor characteristics are, in my experience, not 'exact', so some leeway could be expected in these calculations in practice.

So, I decided to try two CZ1 thermistors (photo, left), in place of the two 270ohm resistors that someone had replaced the original CZ2 thermistors with.

The result was a longer warm-up time - around 1.25mins for audio to appear (as expected) - with around 55v at the 'hot' end of the heater string, less bright switch-on dial light glow, and a voltage of 86.5v at the 'hot' end of the heater string when fully warmed-up (I found this voltage reached around 84v within a couple of minutes, then slowly crept up to 86.5v over the next 5 minutes or so). I checked a few individual heater voltages and these were now much closer to the 6.3v and 13v needed.

The two CZ1 thermistors (in parallel) were running at an average temperature of around 140C (one at 108C and one at 170C) when the set was fully warmed-up, which corresponds to around 160ohms (each) on the CZ1 resistance temperature characteristic curve. Allowing for them to be in parallel with the 330ohm power resistor would give a combined resistance of around 65ohms. I measured the resistance across them immediately after switching the set off and I measured around 70ohms, so quite close to spec. The resistance across the thermistors, and the 330ohm resistor in parallel with them (plus the B+ line to ground) when cold was 133ohms, and 287ohms when disconnected from the heater string (V11 pulled). The latter resistance corresponds to the two CZ1 thermistors having a nominal resistance of 4.5Kohms each at room temperature (20C) with them in parallel with the 330ohm power resistor.

With the heater string issue resolved, my next job was to replace the tubular electrolytics and audio coupling capacitors, check for leakage on a sample of the other tubular paper capacitors, and the values of some resistors as indicated by the out of tolerance voltages.

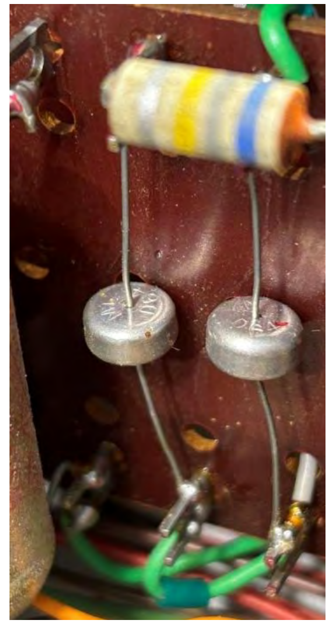
Initial Component Replacement

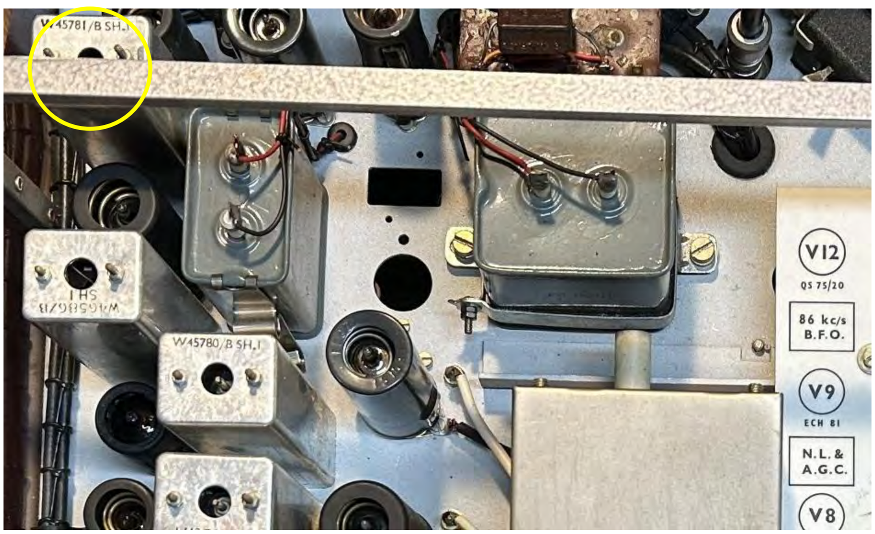
I initially replaced the two tubular electrolytics, six of the metal clad tubular paper capacitors, and 18 resistors. The electrolytics I removed had both failed – the 50uF output stage cathode bypass capacitor, dated April, 1965 (photo, right), measured 140uF with almost 2mA leakage (photos, below), and the 20uF 1st AF stage cathode bypass capacitor had no measurable capacitance and 4.3mA leakage at half its rated working voltage. All the paper capacitors replaced were close to their nominal values but were leaky. I checked most of the resistors, and they were all within tolerance apart from the ones I changed. None were too far out of tolerance – the worst was around 20% off its nominal value. There were several resistors I had not yet checked, but planned to do so later. I suspected that most of the remaining tubular paper capacitors in the chassis were probably leaky also. I checked a few at random, and all leaked between around 2uA and 8uA at 100vDC. There were around another 26 in total, mostly 0.1uF parts. I recommended to the owner that they should probably all be replaced during the refurbishment and he agreed.

The initial component changes noted above fixed a few of the voltage discrepancies on the tube sockets noted previously, but not all, and there were some issues I found that needed to be resolved. For example, I checked the AGC voltages and no AGC was being applied to the RF stages, and the IF AGC level generated by a very strong local signal was peaking at only around -3.3v – I would have expected more like -15v. As is typical, such an issue results in some distortion of the audio - I had noticed this distortion before, but thought it might be due to a leaky audio coupling capacitor - both had now been changed, so that was not the problem.

AGC Troubleshooting

Preliminary investigation identified that one small signal selenium rectifier was open circuit ('MR1' – the left hand one in photo, right), and that explained the lack of AGC being applied to the RF stages as this rectifier (part of the de-sensitizing circuit) is in that AGC line. The other three readily accessible small signal selenium rectifiers measured very high resistances (megohms). Two of these were in the noise limiter circuit ('MR3' and 'MR4'), and one in the desensitize circuit ('MR2'), though none of these having a high resistance should affect the AGC operation. The two small signal selenium rectifiers that actually generate the AGC voltage from the 85KHz IF signal ('MR5' and 'MR6'), are located in the 'Noise Limiter and AGC Assembly' ('AGC Assembly'), which resembles the IF transformer cans. Access to these and their associated components (several resistors and capacitors) necessitates removal of the AGC Assembly containing them from the chassis.





Prior to removing the AGC Assembly from the chassis (circled in photo, left), I was able to do a rough test of 'MR5' (providing delayed AGC to the two RF stages) by measuring resistances between terminals on the AGC Assembly, and 'MR6' (providing both AGC to the 1st IF stage, and a bias voltage for the noise limiter circuit), without removing the can from the chassis. 'MR5' appeared to be rectifying (also confirmed by some RF stage AGC is being produced, but not delivered due to failure of MR1), but had a high internal forward resistance (around 220Kohms), but not as high as 'MR3' and 'MR4', these measuring around 2Mohms to 4Mohms respectively. This rough test also indicated that 'MR6' could be shorted if an associated 0.1uF capacitor to ground was not leaking badly, or high resistance in both directions if that capacitor was very leaky. However, I really needed to remove and open up the AGC Assembly and check/replace parts as needed. I did change out the accessible AGC smoothing/time constant capacitors (both were leaky), but another two 0.1uF capacitors were lurking inside the AGC Assembly, including the one associated with 'MR6'.

While investigating the AGC issues, I also suspected there was a problem(s) in the RF section of the receiver, at least on Band 6 (reduced sensitivity compared with other bands) – maybe an open circuit antenna coil, tarnished switch contact, etc. but I decided to investigate that later.

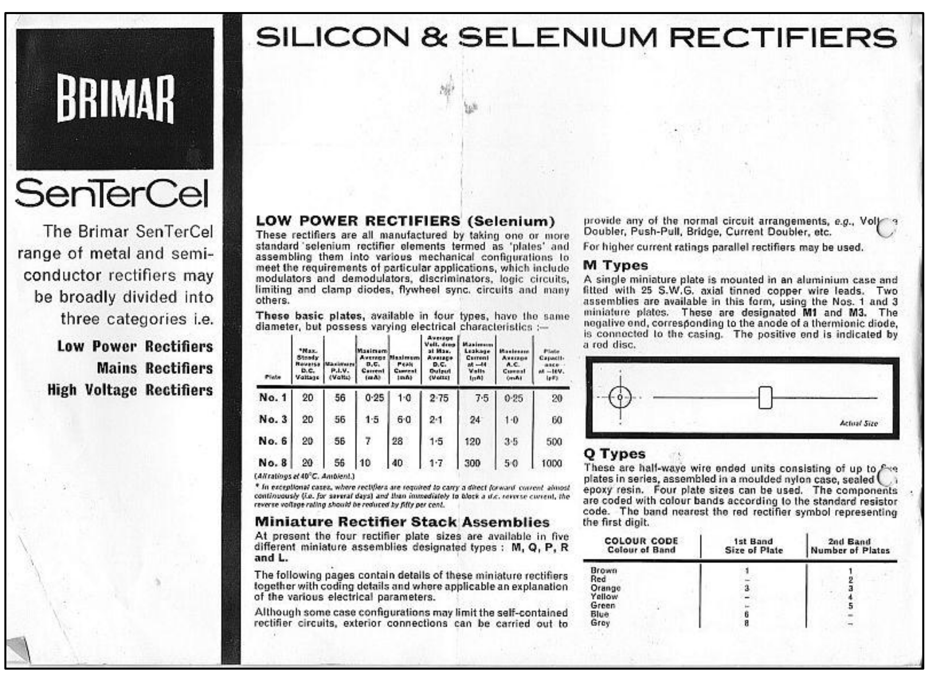
Small Signal Selenium Diodes

I decided that all the small signal selenium diodes should be replaced, however, I had never done that before - I had only replaced selenium power rectifiers, where a series resistor of 120ohms or so is usually appropriate to mimic the higher internal forward resistance of the selenium element compared with silicon. I was concerned that the selenium rectifier characteristics were needed to provide correct circuit operation, eg. the manual notes that the internal resistance of 'MR6' provides a small delay to the IF AGC. I figured that maybe silicon diodes, eg. 1N4148s, or germanium diodes, eg. OA90s, with a suitable series resistor may be able to mimic the selenium diode characteristics, but decided to experiment a little before installing replacement diodes into the chassis.

So, I went trawling in my junk box and sorted out a selection of diodes: a batch of germanium diodes – some OA90s and OA91s having a forward threshold voltage of around 0.3v, and some really old (germanium) OA10s, probably dating back to the 1950's - they were still working though, with a threshold voltage of only 0.25v. I also found some much more modern Schottky (silicon) diodes (5819s) that also have a threshold voltage of 0.25v, plus oodles of 1N4148s with a 0.6v threshold voltage.

To experiment, I built a replica of the circuit contained inside the AGC Assembly onto a breadboard that could be subbed for the actual AGC Assembly by removing the wires from the AGC Assembly while it was still installed on the chassis, and clipping on some flying leads from the breadboard to the wires. If this worked, I planned to remove the AGC Assembly from the chassis and re-build the internals with the diodes (and series resistors if needed) that I found worked best.

In the meantime, the owner of the Atalanta found a thread on the UK Vintage Radio Repair and Discussion Forum discussing the Atalanta, including some comments on replacement of the small signal selenium rectifiers (link here). It appeared that 1N4148 silicon diodes would work, though likely with different AGC characteristics than the selenium devices, much as I had surmised earlier. The thread also provided a link (here) to some info about the selenium diodes - they are Brimar 'SenTerCel' single selenium plate parts (Brimar info. sheet, right). Unfortunately, this info



SILICON & SELENIUM RECTIFIERS

BRIMAR

SenTerCel

The Brimar SenTerCel range of metal and semi-conductor rectifiers may be broadly divided into three categories i.e.

Low Power Rectifiers
Mains Rectifiers
High Voltage Rectifiers

LOW POWER RECTIFIERS (Selenium)

These rectifiers are all manufactured by taking one or more standard selenium rectifier elements termed as 'plates' and assembling them into various mechanical configurations to meet the requirements of particular applications, which include modulators and demodulators, discriminators, logic circuits, limiting and clamp diodes, flywheel sync. circuits and many others.

These basic plates, available in four types, have the same diameter, but possess varying electrical characteristics :—

Plate	*Max. Steady Reverse D.C. Voltage	Maximum P.I.V. (Volts)	Maximum Average D.C. Current (mA)	Maximum Peak Current (mA)	Average Volt. drop at Max. Average D.C. Output (Volts)	Maximum Leakage Current at —14 Volts (μA)	Maximum Average A.C. Current (mA)	Plate Capacitance at —10V. (pF)
No. 1	20	56	0·25	1·0	2·75	7·5	0·25	20
No. 3	20	56	1·5	6·0	2·1	24	1·0	60
No. 6	20	56	7	28	1·5	120	3·5	500
No. 8	20	56	10	40	1·7	300	5·0	1000

(All ratings at 40°C. Ambient.)

** In exceptional cases, where rectifiers are required to carry a direct forward current almost continuously (i.e. for several days) and then immediately to block a d.c. reverse current, the reverse voltage rating should be reduced by fifty per cent.*

Miniature Rectifier Stack Assemblies

At present the four rectifier plate sizes are available in five different miniature assemblies designated types : **M, Q, P, R and L.**

The following pages contain details of these miniature rectifiers together with coding details and where applicable an explanation of the various electrical parameters.

Although some case configurations may limit the self-contained rectifier circuits, exterior connections can be carried out to provide any of the normal circuit arrangements, *e.g.*, Vol[illegible] Doubler, Push-Pull, Bridge, Current Doubler, etc.

For higher current ratings parallel rectifiers may be used.

M Types

A single miniature plate is mounted in an aluminium case and fitted with 25 S.W.G. axial tinned copper wire leads. Two assemblies are available in this form, using the Nos. 1 and 3 miniature plates. These are designated **M1** and **M3.** The negative end, corresponding to the anode of a thermionic diode, is connected to the casing. The positive end is indicated by a red disc.

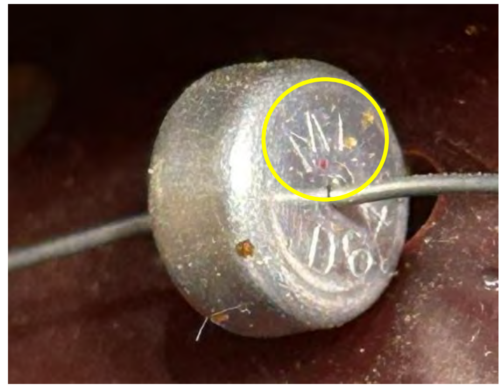
Actual Size

Q Types

These are half-wave wire ended units consisting of up to [illegible] plates in series, assembled in a moulded nylon case, sealed [illegible] epoxy resin. Four plate sizes can be used. The components are coded with colour bands according to the standard resistor code. The band nearest the red rectifier symbol representing the first digit.

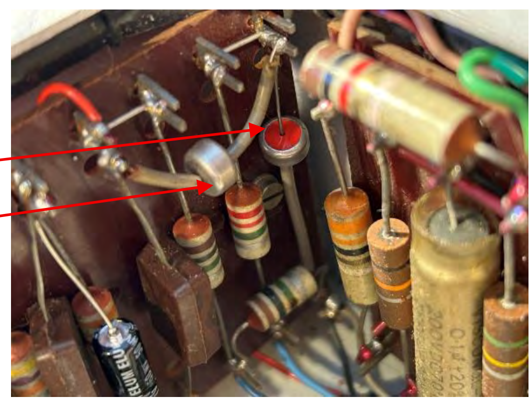
COLOUR CODE Colour of Band	1st Band Size of Plate	2nd Band Number of Plates
Brown	1	1
Red	–	2
Orange	3	3
Yellow	–	4
Green	–	5
Blue	6	–
Grey	8	–

does not provide typical forward and reverse resistance values. However, an estimate of the reverse resistance can be derived from the stated maximum steady reverse DC voltage and maximum leakage current - this can range from 2.7Mohms for the 'M1' selenium plates to 833Kohms for the 'M3' plates, however, this is at 40C. A range of forward resistances cannot similarly be estimated, but I considered less than 10% of these values would be a reasonable estimate. The diodes in the Atalanta are marked as type 'M1' (circled in photo, right), so the maximum forward resistance should be in the order of, say, 135Kohms, based on these assumptions - considerably less than I was measuring in this chassis, indicating degraded performance.



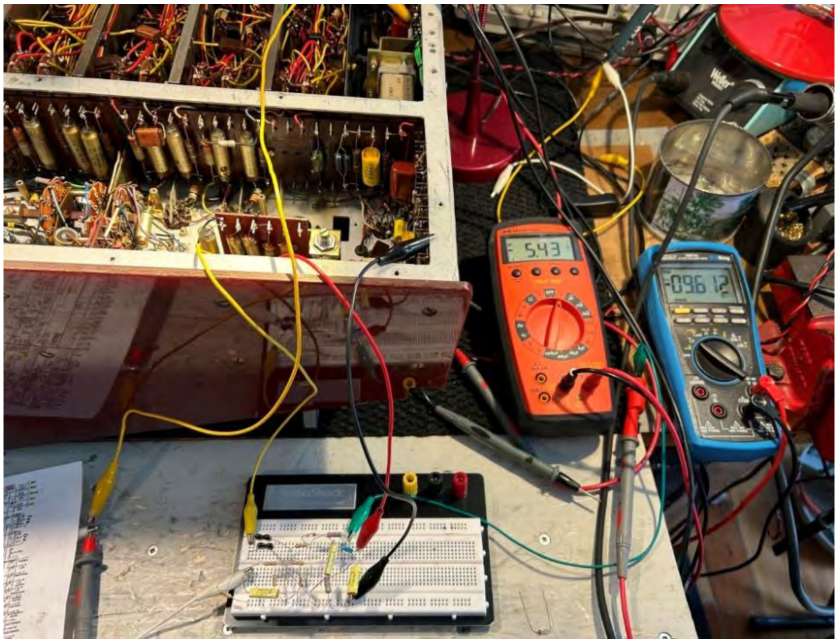
The UK forum thread suggests the voltage drop may be as high as 5v. If this was the case, I would need 8 x 1N4148s in series with, say, a 120Kohm resistor, to mimic an 'M1' diode – in which case the AGC delay voltage on the 1st IF stage would be 5V, which would be much too high for the desired IF stage AGC characteristics (the delayed AGC on the RF stages is 7V), so I figured this could not be correct. The thread also suggested checking the diodes using a 9v battery in series with a 10Kohm resistor and microammeter rather than a multimeter. So, I did a little experimentation first using the suggested 9v battery in series with a 10Kohm resistor and microammeter, then using a variable DC voltage supply. I found that the 'voltage drop' on one of the selenium diodes ('M4') was nothing like 5v (more like 1V). I then used the 9v battery/10Kohm resistor/microammeter to measure each of the selenium diodes. The 10Kohm resistor would limit the maximum current to 900uA, and I measured the following:

Diode	Forward(uA)	Reverse(uA)
'MR1'	200	4
'MR2'	21	5
'MR3	540	2
'MR4'	530	2
'MR5' [25]	30	8
'MR6' [25]	8	6



By this stage I realized that I was likely over-thinking this, and maybe I should just install a 1N4148 or OA90 diode for each of the 'M1' selenium diodes and be done with it - always interesting doing the research and experiments though! That said, I thought I would first try just the IF stage section of the breadboarded AGC circuit to see how much AGC was derived from a strong local signal, and compare it with that derived from the 'MR6' selenium diode (-3.8v). An OA90 germanium diode with a 3.3Kohm

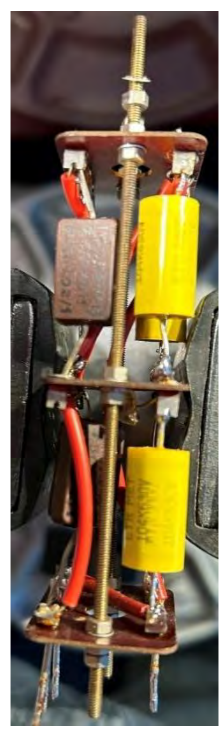
[25] The 'MR5' and 'MR6' diodes are located inside the AGC Assembly screening can, and the figures above need to account for additional series resistors located inside the screening can and, for 'MR6', a 1Mohm resistor in parallel, plus any leakage through the 0.1uF capacitors. For 'MR5', the maximum current would be limited to 86uA and for 'MR6', 19uA (assuming the capacitors are not leaky at this low voltage and that the resistor values in the screening can are within tolerance). This would indicate that 'MR5' had a forward resistance of around 160Kohms (a bit higher than my estimate), and 'MR6' around 818Kohms (much higher than my estimate), that 'MR6' was not acting much like a diode, and that 'MR2' and 'MR5' were not very efficient.



series resistor developed around -14v, and a 1N4148 (without a series resistor) developed around -16v on the same signal. 'MR5', providing the AGC to the RF amplifier stages, was developing only around -0.8v. I tried connecting the -16v from the breadboarded AGC circuit to these stages and the audio distortion vanished. I then jury rigged both the RF stage section and the IF stage section of the breadboard AGC setup into the Atalanta chassis (with the AGC Assembly fully disconnected from the circuit) – photo, left). The RF stage section has a delay voltage applied (around +7v), derived from a voltage divider between the 105vDC B+ and chassis ground. This delay voltage cancels out the AGC voltage to the RF stages until it reaches -7v, and then applies AGC to the RF stages as the voltage developed by the diode (MR5) minus the 7v. This all seemed to work ok, and again, no audio distortion was present.

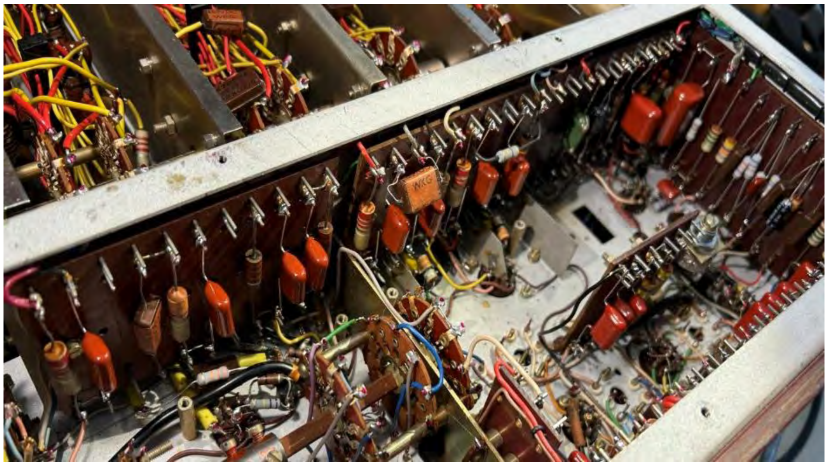
Given the above results, I was confident that installing 1N4148 diodes in place of all the small signal selenium parts, and without any series resistors, would work ok as had been noted in the UK Vintage Radio Repair and Discussion Forum thread.

More Component Replacement

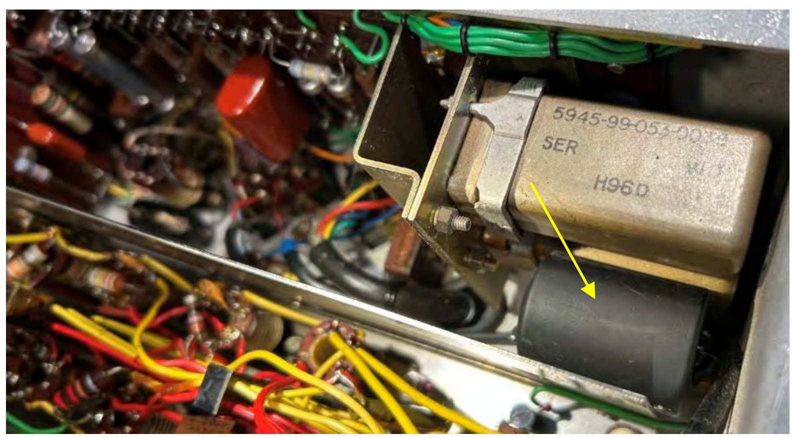


Next, I replaced all the tubular paper capacitors in the AGC Assembly (photo, far right), and the 615KHz local oscillator assembly (photo, near right). While I had these cans open, I also replaced all the resistors in them, as the cans are very fiddly and time consuming to remove/ replace, so best to do some preventative maintenance here. I also replaced the two selenium diodes in the AGC Assembly can using 1N4148 silicon diodes (one visible at the tip of arrow in photo, far right), as well as the four selenium diodes in the desensitizing and limiter circuits located on tag boards attached to the rear apron of the chassis, also with 1N4148s.

Moving on to the tag boards, I used brown-coloured radial lead capacitors to replace all the visible tubular paper capacitors as I felt this looked less 'obtrusive' than a sea of 'yellow jacket' axial lead capacitors in the chassis (photos, top of page 21), and so I also replaced the few 'yellow' jacket' capacitors I had installed previously with brown radial lead ones for uniformity. Re-stuffing all the metal-clad tubular paper capacitors in the chassis would have taken an age, and was not required



by the set's owner. I left the large 2uF tubular paper capacitor located under the two relays near the rear apron in place, as it was going to be a very fiddly job to remove it (removing the relays, etc.), risking damage to some of these parts. So instead, I disconnected one end of this capacitor (the other end is grounded to chassis), and installed a new capacitor between the relays and the antenna section compartment divider. This 2uF part is a 'yellow jacket', but I put some black heat shrink around it so it did not stand out visually (tip of arrow in photo, below right). For the metal-clad tubular paper capacitor mounted on the top of the B+ filter choke, as this is located above the chassis, I re-stuffed the original capacitor (three photos, left), so the top of the chassis looked all-original.



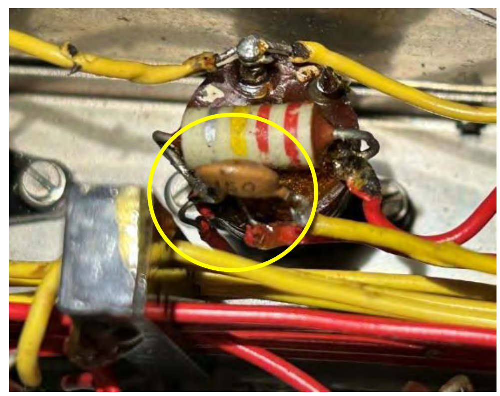
I tested some of the removed parts: all the tubular paper capacitors were leaky, with one (in the AGC/Noise Limiter can) leaking almost 2mA at 100v, with some of the others in the 20 –

50uA range, so all were ready to be changed out. The resistors I removed from within the two cans were mostly out of tolerance – but not greatly, up to around 20% or so. I also made some measurements on the Brimar M1 selenium diodes after they were removed from the chassis. The results are included in the Appendix. By this stage, I had replaced a total of 39 tubular paper capacitors, 2 tubular electrolytics, 27 resistors, and 6 selenium diodes (removed parts shown in photo, right).

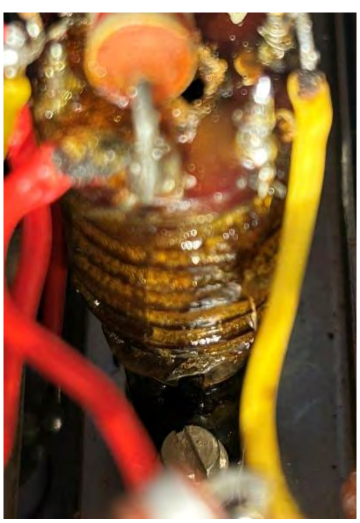
Both the RF and IF AGC circuits were now functioning, the RF AGC being delayed until the AGC voltage reached at least -7V, as it should be, with hardly any delay on the IF AGC, again, as it should be.

Troubleshooting and Repair of the Antenna Circuits

Following the above work on the AGC circuits and component replacements, I investigated the possible fault I had noted in RF section, ie. low sensitivity on Band 6. I checked the primary and secondary DC resistances of the Antenna/1st RF stage transformers on all bands and, sadly, my suspicion that the antenna input transformer secondary on Band 6 (Broadcast Band) was open circuit was correct. This is a bit unusual, as its generally the primary winding (or both) that has been zapped by a lightening strike, static discharge, or a nearby transmitter, etc., but the primary winding checked out ok, measuring 12.7ohms DC resistance. The primary and secondary windings of all other antenna and 1st RF to 2nd RF interstage transformers on all other bands also checked out ok.

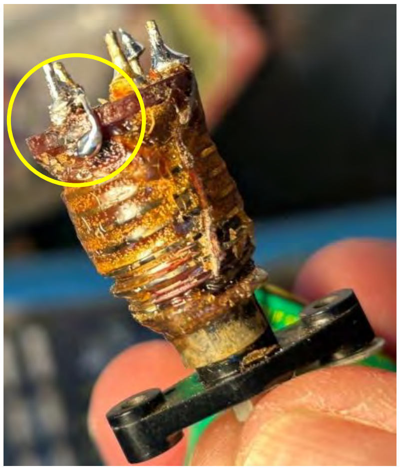


I temporarily 'kludged' the Band 6 antenna input by moving the end of a 150pF disc ceramic capacitor (C187) from the 'hot' end of the primary to the 'hot' end of the (open circuit) secondary (capacitor circled in photo, above right), thus bypassing the transformer. With this kludge effected. there was now much better reception on Band 6, though, of course, the antenna input on this band was now untuned, so performance would be degraded compared to if the transformer was functional. The Band 6 antenna transformer did not look damaged/scorched (photo, left), so I considered that it was possible that one of the connections from the fine gauge wire to the terminal had snapped or corroded rather than the windings being fried. I next checked all the remaining RF interstage transformers and tabulated the results along with comments (included in the Appendix). No other open-circuit windings were noted: allowing for any series resistors on some bands (as indicated in the table comments), and any minor switch contact resistance (varies slightly



between switch contacts), they all look reasonable, apart from the Band 6 Antenna/1st RF stage grid transformer secondary winding as noted previously[26].

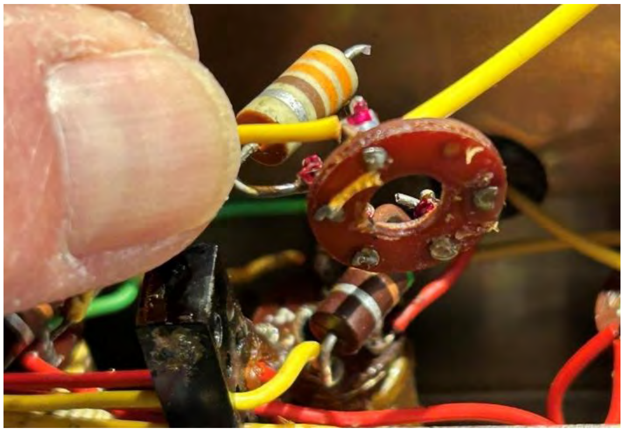
Band 6 Antenna Transformer Checks and Repairs



I removed the Band 6 antenna transformer (L7) and, after some very careful probing and scraping away at the hard cement they used to seal this coil with, found that the end of the secondary winding had come away from pin 3 on the coil former. The wire used for that winding is not Litz, but very fine enamel-coated stranded wire. I teased-out as much of the end of the winding as I could (of course it was the end that vanishes into the inside of the coil), scraped the enamel off, added some liquid flux, managed to tin the wire strands, then checked the winding continuity – this checked ok. I then wrapped and soldered a short piece of wire to the top of pin 3 on the former, bent it down over the windings and soldered the end of the secondary winding to it (circled in photo, above right). I also installed a new 220Kohm damping resistor across the secondary winding (between pins 1 and 3) – photo, left. The secondary winding resistance measured 2.92ohms, which was around the value I had estimated based on the Band 5 and Band 7 secondary resistances (8ohm and 0.9ohm respectively – see Appendix). Judging by soldering iron 'scars' on the insulation of several pieces of nearby connecting wires, and a missing washer from one of the mounting screws on the coil former base, someone had already had this transformer out of the chassis – probably tried to see if they could fix it, gave up, and reinstalled it.

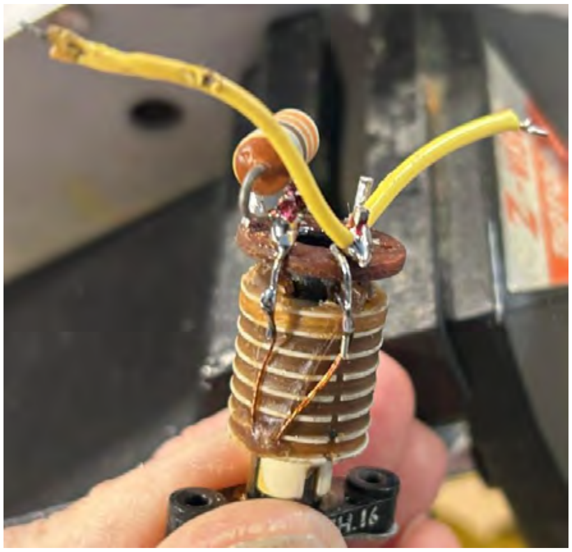
A Band 4 '*Faux Pas*' And Repair

As I was re-installing the repaired Band 6 antenna transformer, I gave a slight pull on the (yellow-insulated) wire connecting pin 5 of this transformer (L7) to pin 5 of the Band 4 antenna transformer (L5) – moving it closer to the pin for soldering. In doing so, the top of the Band 4 antenna transformer former pulled clean off (photo, right), detaching all four very fine wires from the transformer windings - horrendous collateral damage!



So, I then had to remove the Band 4 antenna transformer and effect even more intricate repairs to that, and four times the work on the Band 6 antenna transformer(!). The top of the Band 4 antenna transformer former (where the

[26] Note that the 1st RF stage is not used on Bands 3, 4, and 5, and the plate circuit of the 1st RF amplifier tube is disconnected by the band change switch on these bands, with the secondary windings of the Antenna/1st RF stage transformers being connected directly to the primary windings of the 1st RF/2nd RF interstage transformers

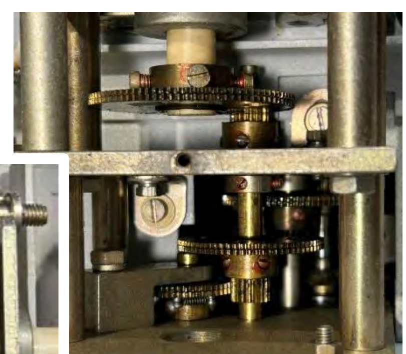


connecting pins are located) cannot have been fixed securely to the plastic tube the windings are wound around for it to detach as easily as it did. I cleaned off the thick soft wax around the top of the former tube (I think this is all that had been holding the top of the former in place), cleaned the top of the former and top of the tube with naphtha, and then IPA, before gluing the top of the former securely in place on the top of the plastic tube with 2-part epoxy. I then repaired each of the four connections as I had done for the detached wire on the Band 6 antenna transformer (photo, left), and also epoxied the pins in place onto the top of the former as I found that they rotated (a rotating pin when manipulating the connecting wires into place could result in a coil winding being broken again!). I also replaced the 330ohm series resistor in the Band 4 antenna transformer primary circuit.

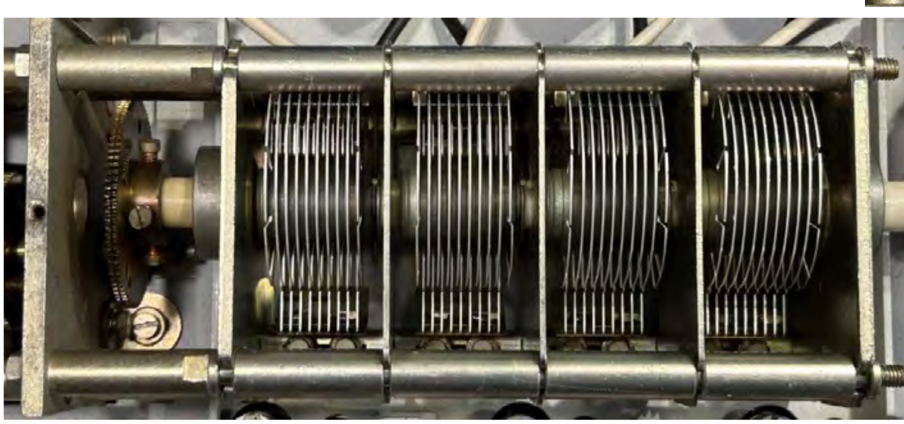
After repairing and re-installing the Band 4 and Band 6 antenna transformers and connecting them back into the circuit, their in-situ winding resistances checked out ok, and both bands were working as they should. The sensitivity on Band 6 (Broadcast band) was now much better than it was with my temporary 'kludge', and with a strong local station tuned in, the IF AGC running at -13v, 2nd RF stage (delayed) AGC at -8v, and 1st RF stage (delayed and reduced by a voltage divider) AGC at -4.5v: all these seemed very reasonable.

The chassis was subsequently left on soak test for most of the following day, during which I made a couple of short videos. The first provides a demonstration of how the 700KHz calibrator is used to set up the Marine Band bandspread dial to work in conjunction with the main dial (here). The second video demonstrates the automatic noise limiter and its effectiveness on noise from switch mode power supplies, LED lights and the like on the LF bands (here).

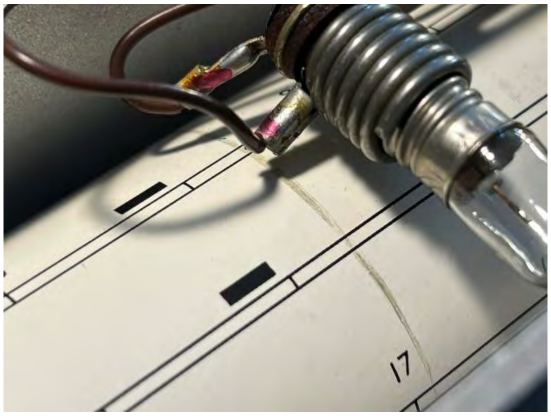
More Clean-up and Checks



Next, I cleaned and re-lubricated the tuning gang and gearbox (photos right and below), and the fine tuning control. I also cleaned behind the dial glass, and dusted the main tuning scale. I noted that a vertical score line on the main tuning scale had been caused by one of the dial bulb holder solder lugs contacting the dial while



it was rotating - an old problem that someone had subsequently fixed, however, the score line in the dial remained (photo, right). I also checked the dial bulbs and they were (surprisingly) of the correct 4v type.



When is a 'Spur' not a 'Spur'?

Finally, prior to undertaking full realignment of the chassis, I checked that the receiver was functioning on all bands (bottom, mid and top of each of the ten bands) – it was. However, one issue I did note during this check was that there appeared to be spurs present at approx. 370KHz intervals on the HF bands – this needed investigating (possibly an artefact, eg. beat with a local station, due to incorrect adjustment of an IF trap?). The spurs were at a low level, and manifested more of a 'burbling' noise rather than a pure carrier signal, which made me think it was either a local station beating with an oscillator in the set, eg. the 615KHz 2nd local oscillator, or a parasitic of some sort. A video demonstrating these apparent spurs can be viewed here.

I realized that had forgotten to install the two small screening plates over the base of the RF tube sockets, so I installed those – doing this seemed to weaken the spurs, but they were still present.

However, after further investigation, I found that the 'spurs' were not spurs at all, but RFI from my OWON bench DMM! (photo, left). I had been using this handy DMM to keep an eye on the voltage being fed to the Atalanta from the home brew power supply, so it was always switched on when the receiver was operating. However, after a session checking various bands for the spurs, I happened to switch the OWON DMM off while the receiver was tuned to one of the spurs (on 19.966MHz, which was one of the stronger ones), and the spur vanished. I tuned around the bands, and the spurs had all gone. I switched the OWON DMM back on and they all reappeared! I did a double check with a couple of small solid-state receivers – one tuned to 19.966MHz, and the other to 370KHz, and they picked up the same RFI – see video here. Strangely, the Atalanta was receiving the interference from the OWON DMM with or without an antenna connected, likely because the chassis base plate was absent, and/or, the RF trimmers are all exposed above the chassis. So, placing the receiver into its cabinet should solve any similar issues in the future.

Re-alignment

Description of the alignment process takes up an impressive nine pages of small text in the Atalanta manual, and (for the most part) is one of the most detailed alignment procedures I have seen for what is a fairly straightforward double-conversion tube receiver. That said, some of the text is devoted to checking things like 'detector efficiency', AGC voltage checks, and audio frequency response.

Alignment Procedure

In essence (and in theory), the alignment procedure is reasonably straightforward, but in practice it takes some time due to a number of reasons noted below.

In summary, the procedure comprises:

- Audio frequency checks*;
- AF sensitivity*;
- AF response*;
- Sidetone level*;
- 2nd IF (85KHz) IF alignment (including finding the resonant frequency of the 'magneto-restrictive resonator' - this is 85.15KHz in this receiver);
- 85KHz IF sensitivity checks;
- 85KHz IF selectivity checks;
- Detector efficiency check;
- AGC voltage checks;
- Detector balance adjustment (the Atalanta has a balanced detector circuit);
- BFO adjustment;
- Comparison between MCW and CW signals*;
- 85KHz switched IF checks*;
- 1st IF (700KHz) alignment;
- 700KHz IF gain check;
- 700KHz IF selectivity check;
- 2nd local oscillator (615KHz) adjustment;
- Overall IF checks;
- 1st local oscillator alignment;
- RF circuit alignment (including IF trap adjustments);
- Noise output check*;
- Image and IF rejection checks*;
- Signal to noise ratio checks**;
- Overall AGC checks;
- Improvement of signal to noise ratio*; and
- CW limiting and stability checks*.

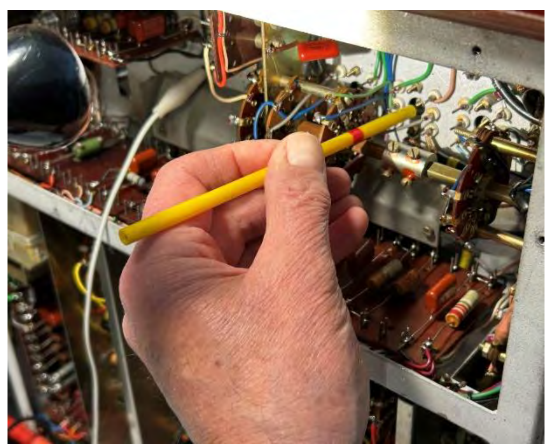
I skipped over (or partially skipped over) a few of the above steps (marked with an asterisk), as although the check described can be carried out, if the receiver does not comply, there is not much that can be readily done about it - only if there was a significant underperformance would further investigation as to the cause be needed. I also abbreviated some of the steps (two asterisks), where extensive checking of performance is described at multiple points on each band, and used a different approach to some of the steps, eg., confirming the alignment is not on an image frequency, by using modern tools, eg. a TinySA.

The RF section tracking points for each band is given as a point on the main dial logging scale (tip of arrow on the photo, below right), rather than at specific frequencies, so I identified a frequency close to the logging scale points noted and used these for the RF alignment, these being:

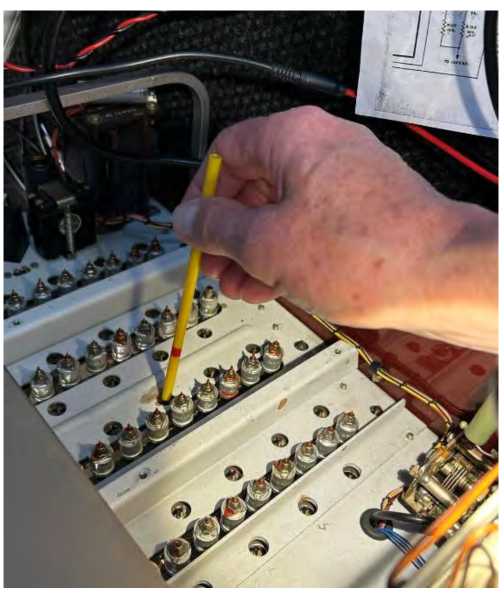
Band	Bottom	Top
1	16KHz	25KHz
2	30KHz	100KHz
3	100KHz	200KHz
4	200KHz	400KHz
5	420KHz	800KHz
6	850KHz	1.7MHz
7	1.8MHz	3.5MHz
8	3.7MHz	7.5MHz
9	8.0MHz	15.0MHz
10	16.0MHz	27.0MHz

These seemed to work well, with good tracking obtained on all bands. Most of the IF and RF trimmers and slugs were close to their optimal positions, with the most adjustment being needed on the 3rd 85KHz IF transformer, the BFO, 2nd local oscillator (615KHz), the 1st local oscillator on Band 6, 8, 9 and 10, and a few of the RF amplifier stages.

Alignment Issues

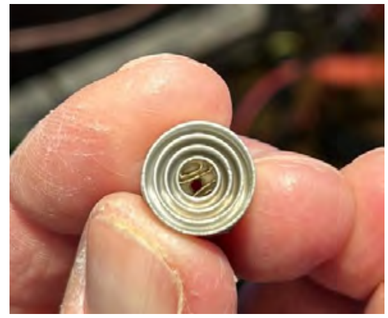


From a practical point of view, I found that adjustment of the slugs in the IF transformers and RF stages to be very time-consuming (photos right and left): the small adjustment screws all have lock nuts on them[27]. The problem is that when re-locking these, even though only a light torque should be applied, doing this often disturbed the slug adjustment, leading to many adjustments having to be repeated several times, with a deliberate 'overshoot' on the adjustment that would be

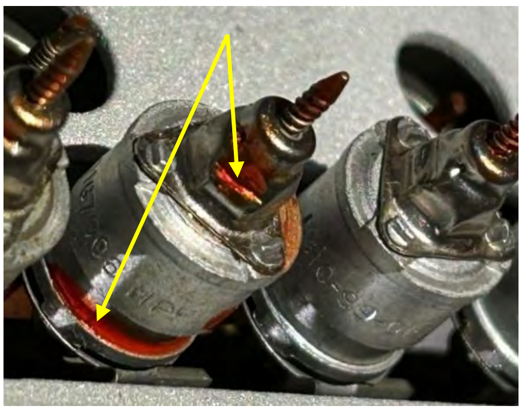


[27] These are British sizes (mostly 8BA, but with some 6BA in the RF stages). Luckily, I have a set of BA socket wrenches I purchased many years ago when I was working a lot with (British) Eddystone receivers, and these tools came in very handy

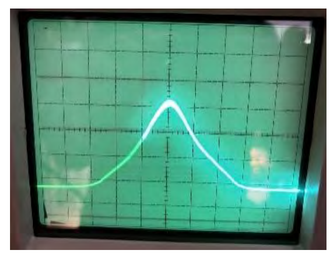
corrected when the locknut was turned (very frustrating and time-consuming). I suspect that Marconi had a special tool for this that held the slug securely while the locknut was torqued.

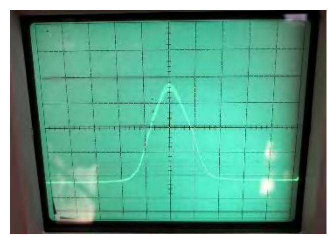


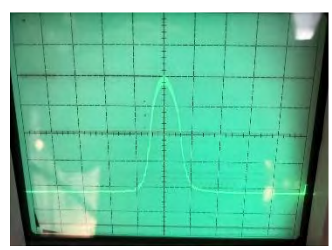
The 'beehive' trimmers in the RF deck were all trouble-free, apart from one that had (inexplicably) some dirt/swarf inside it that caused noise while adjusting (photo, right) - I removed the top of the trimmer and cleaned it, and one (mixer stage trimmer on Band 4), where whoever sealed it last (possibly the factory), had used so much sealant that it had flooded the trimmer and it was stuck tight (tip of arrows in the photo, left). I tried to free it, but was concerned I was going to cause damage. I considered removing it and replacing it, but as the sensitivity on that band was comparable to the others, I decided to leave well-alone and maintain originality.

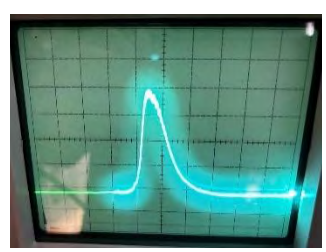


IF Response Curves







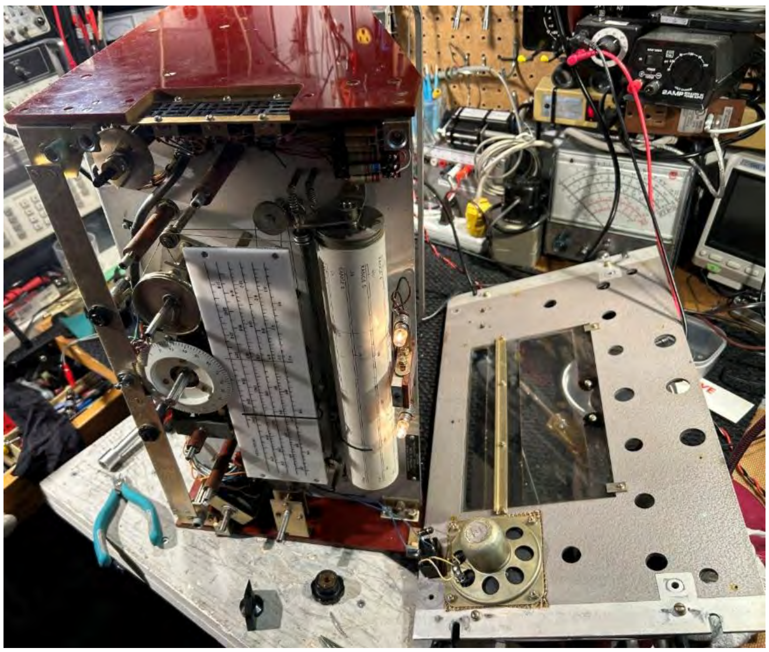


After completing the alignment procedure, I decided to check the shape of the 2nd IF (85KHz) response curves for each of the four selectivity positions ('Wide', 'Intermediate', 'Narrow' and 'Very Narrow'). I would normally do this using a Siglent spectrum analyzer and tracking generator. However, the tracking generator in the Siglent model I have only works down to 100KHz, so, instead, I used an HP8601A sweep generator (with an HP8600A digital marker generator), and a Tektronix 604 monitor.

Using the HP8601A below 100KHz, especially when sweeping, is really pushing its limits, but I have done this before and knew it could be done. However, the markers do not work reliably at this frequency, so it is a qualitative indication only of the response curves. The IF response curves for the 'Wide', 'Intermediate', 'Narrow' and 'Very Narrow' selectivity settings are shown in the photos, right (widest at the top) – apologies for the faint images on two of the photos. A video demonstrating this can be viewed here. This indicated that the IF response curves are symmetrical and that the bandwidths reduce as expected as each selectivity position is selected. The curve shape on the 'Very Narrow' setting (photo, bottom right), includes some 'ringing' and a decay artefact that I have noted before when using the HP8601A on narrow bandwidth filters - I am sure that the actual response curve does not contain the latter.

Final Repairs and a Small Modification

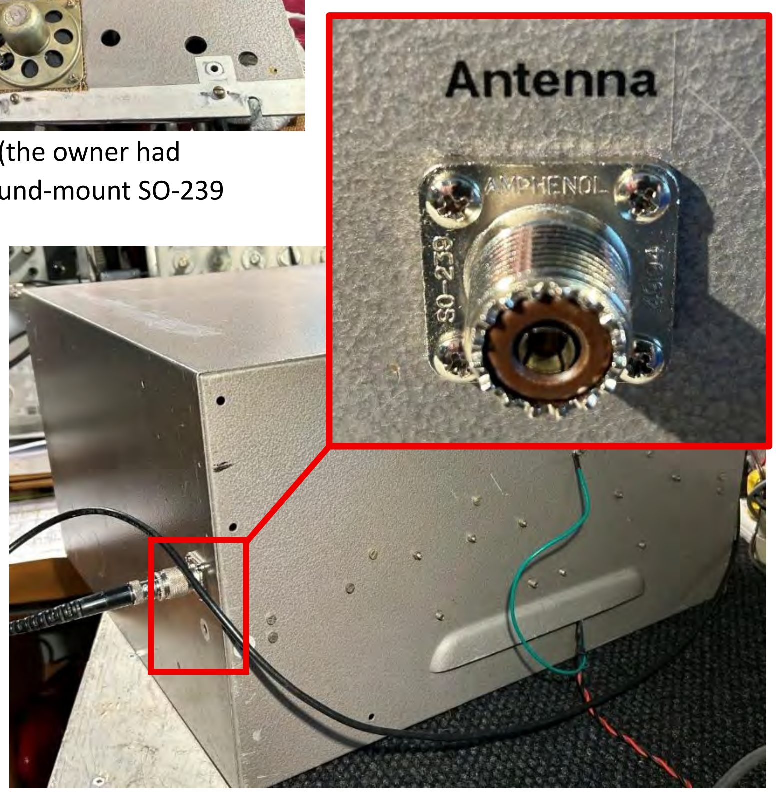
During the alignment, I noted that the AF gain control was not functioning well at its lower end ('all or nothing' syndrome). I had cleaned this pot using a squirt of Deoxit D5 during the refurbishing work, but had ignored the issue at that time. So, after completing the alignment, I removed the knobs and front panel and replaced this pot. This is a 2Mohm log-taper part, and had been replaced previously with ('Made in USA') linear-taper part, so no wonder the volume could not be adjusted easily at the low end of its travel. I did not have a 2Mohm log-taper pot in stock, but found the required components to make one in a NOS 'IRC' pot kit (photo, right). While the front panel was removed from the chassis (photo, below), I cleaned the rear of the main and bandspread dial covers with anti-static



cleaner, and cleaned all the knobs and fingerplates before refitting the front panel and knobs to the chassis.

I had also noted that the speaker on/off toggle switch was intermittent in operation, so I squirted some Deoxit D5 into it with the chassis front pointing upwards, and worked the toggle several times – this resolved the problem.

Next, I replaced the Belling-Lee antenna socket on the Atalanta cabinet with a new Amphenol SO-239 socket (the owner had requested this). I did not have any round-mount SO-239 sockets in stock, so I fitted a standard bulkhead socket (photos, right). This entailed widening the centre hole and drilling four small mounting holes for the screws. I prevented swarf entering the cabinet during the drilling by using a plastic cup mounted onto the cabinet with masking tape.



The original carbon composition static discharge resistor across the antenna socket checked out ok, so I reinstalled it across the new socket. I replaced the 0.1uF capacitor on one of the terminal blocks in the cabinet as this measured slightly leaky. I tested the 2uF metal clad paper capacitors in the filter, and the 32uF electrolytic capacitor[28] mounted inside the rear of the cabinet - all these capacitors checked out ok, so I left them in place.

I then wired the power supply wires into the 'brute force' filter input, added a ground wire to the filter that could be attached to the cabinet via a solder lug and nut (photo bottom of page 29), installed the chassis into the cabinet, and left it on soak test for a few hours – all was ok. I then temporarily removed the chassis (partly) from the cabinet and found that for a nominal 105vDC on the B+ rail, around 109vDC was needed at the power supply output terminals (the voltage drop is through the filter choke on the receiver chassis). I also checked/tweaked the BFO frequency slightly to the specified 86KHz using a DFM to provide a 1KHz beat when a CW signal is tuned in as I had found the earlier adjustment to be a little on the low side of optimal when using the receiver on soak test.

Final Checks

With the chassis re-installed in the cabinet, I left the receiver on soak test for a day, occasionally changing bands and operating various controls – no issues were noted. The following morning, after a warm-up drift check (very little drift noted after the first half hour), I carried out semi-qualitive sensitivity checks on AM and CW at the bottom, middle and top of each band. These were all undertaken with the 'Narrow' (1KHz bandwidth) selectivity setting – see table, right.

Marconi Atalanta S/N 3376 Semi-quantative Sensitivity*

Band	Bottom		Mid		Top	
	AM	CW	AM	CW	AM	CW
1	<0.45uV	<0.2uV	<0.25uV	<0.09uV	<0.2uV	<0.13uV
2	<0.45uV	<0.09uV	<0.25uV	<0.07uV	<0.2uV	<0.07uV
3	<0.2uV	<0.09uV	<0.15uv	<0.07uV	<0.15uV	<0.05uV
4	<0.15uV	<0.04uV	<0.15uV	<0.03uV	<0.15uV	<0.04uV
5	<0.15uV	<0.05uV	<0.15uV	<0.03uV	<0.2uV	<0.07uV
6	<0.25uV	<0.07uV	<0.2uV	<0.03uV	<0.15uV	<0.025uV
7	<0.1uV	<0.025uV	<0.15uV	<0.02uV	<0.1uV	<0.015uV
8	<0.1uV	<0.01uV	<0.15uV	<0.015uV	<0.1uV	<0.015uV
9	<0.1uV	<0.01uV	<0.15uV	<0.01uV	<0.1uV	<0.01uV
10	<0.1uV	<0.02uV	<0.15uV	<0.015uV	<0.1uV	<0.02uV

* Minimum signal strength audible above noise

In summary, the receiver was performing very well on all bands with very good sensitivity, and generally well balanced between and across all bands. I noted that even with the chassis installed in the cabinet, some RFI was noticeable on the VLF bands that likely degraded the apparent sensitivity figures slightly on these bands.

With that, I gave the cabinet a polish with Novus #2/#1, and the receiver was then packed up ready for shipping back to its owner.

Closure

The Marconi Atalanta is a very nice general coverage 'no-nonsense' receiver with extended coverage down to 15KHz on the VLF bands. It has good sensitivity, combined with reasonably good image rejection, and the four selectivity positions provide a useful range of bandwidths for AM and CW

[28] This is actually 'C1' in the power supply Type 2202A circuit, so one of these power supplies may have been fitted into this cabinet at some time

reception. Its use for SSB reception is limited without modification[29] as the BFO is fixed on the upper side of the IF frequency, thus allowing correct demodulation of only one sideband. The sophisticated AGC circuitry works well, as does the noise limiter. The marine bandspread dial is effectively redundant some six decades after the set was designed, but attests to the receiver's provenance, and adds to the character of the set.

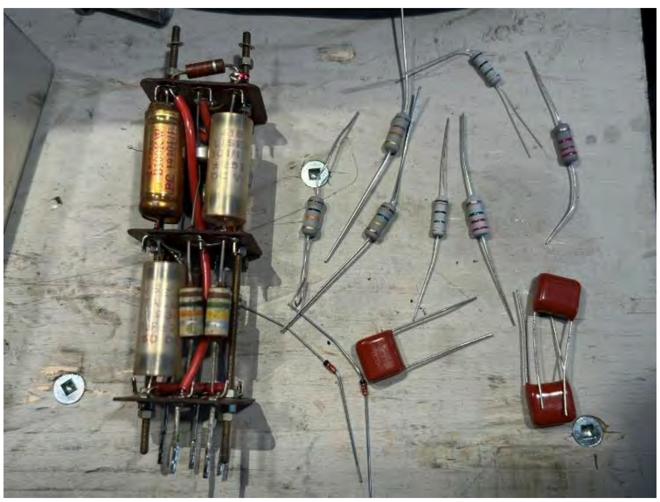
The set's overall superlative build quality and general easy of servicing are worth a mention, albeit with a little skimping by the use of phenolic band change switch wafers (although the wafers used are robust and have stood the test of time). Top quality passive parts were used in the construction – in the Atalanta sets I have seen, few, if any, parts had been replaced during the years of use[30] – likely at least a decade or two of 24/7 operation aboard ship/shoreline installation, followed by years of use/abuse in ham shacks and poor storage conditions. Only after many decades have the electrolytics, metal clad tubular paper capacitors and some resistors deteriorated to the point that replacement was necessary to maintain performance and reliability – far beyond the 'normal' five to ten years of service life of such a set.

[29] A number of options for this are possible, eg. providing a front panel BFO pitch control, or using the spare position on the 'System' switch (clockwise of the 'Phone' position), to switch in a capacitor to alter the BFO pitch by a fixed amount, say 1KHz, below the IF frequency – this method would have the advantage of not requiring any 'butchering' of the front panel

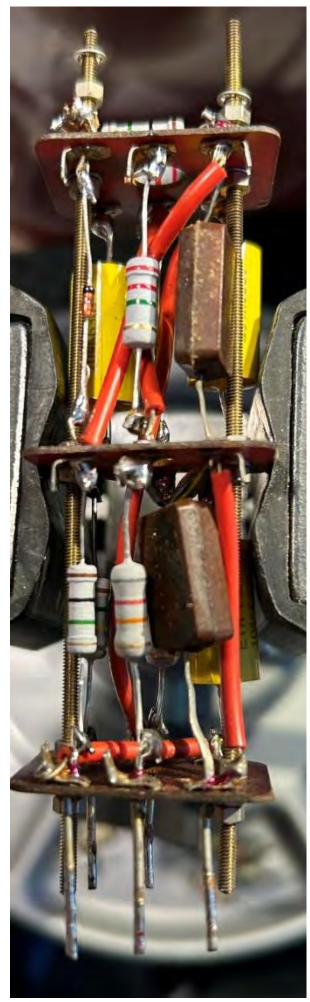
[30] This chassis had only two of the thermistors replaced with resistors on arrival at my 'shop

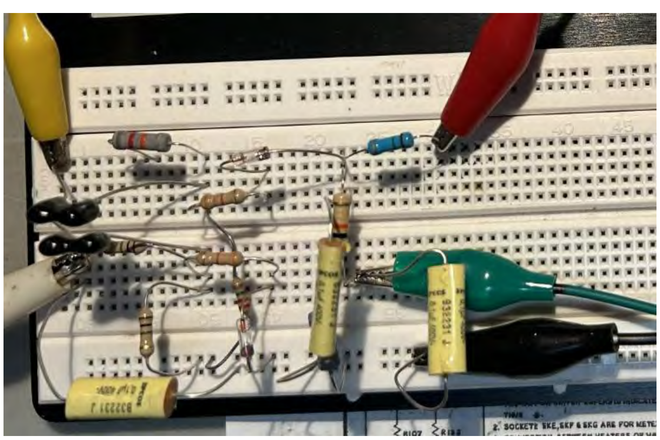
[31] The Type 2207C 'Atalanta' was also designated as Type 'NS.702'. In the NS.702, the six marine bands were not engraved on the 'Traffolyte' bandspread dial, which could be engraved by the purchaser, or replaced/overlain with a paper scale to suit their requirements. There were also several variants of the 2207, eg. 2207B, 2207D (same as the 2207C with the muting circuit fitted), and 2207E

Above top left/right: disassembled 'AGC Assembly' – note the small signal selenium diodes

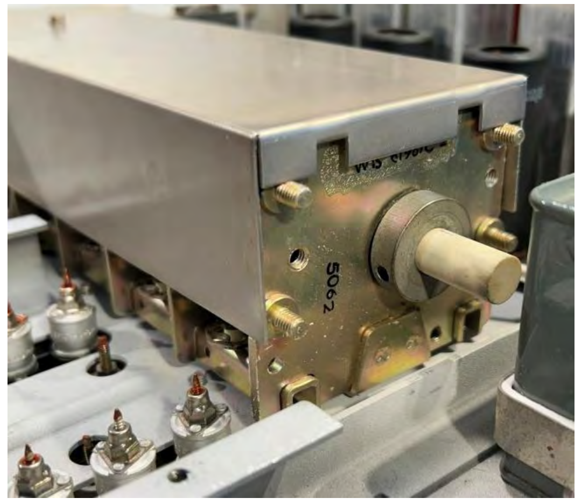


Above: assembling the parts needed to replace the components in the 'AGC Assembly' (I subsequently decided to use axial lead capacitors as these suited the layout better)

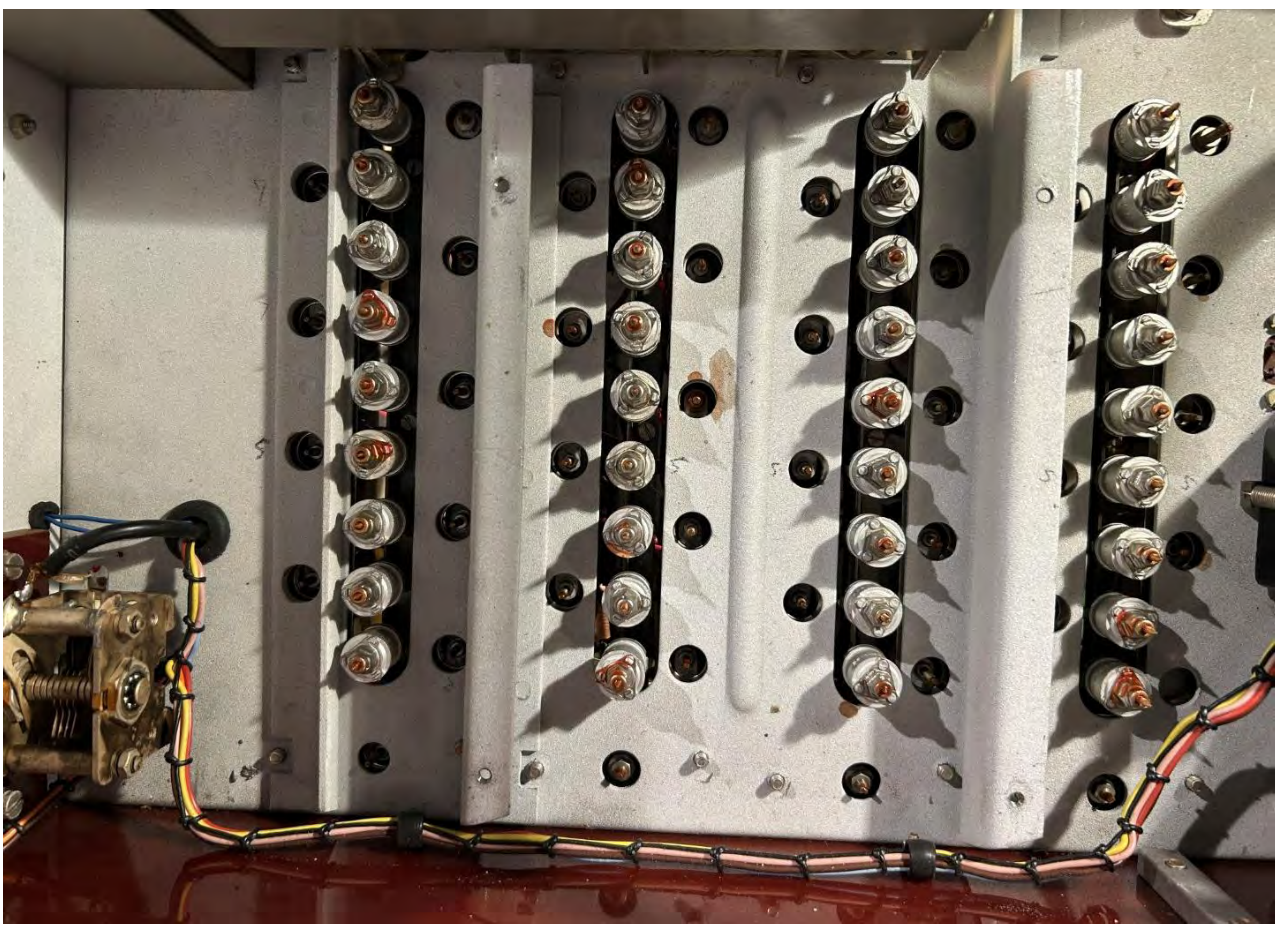


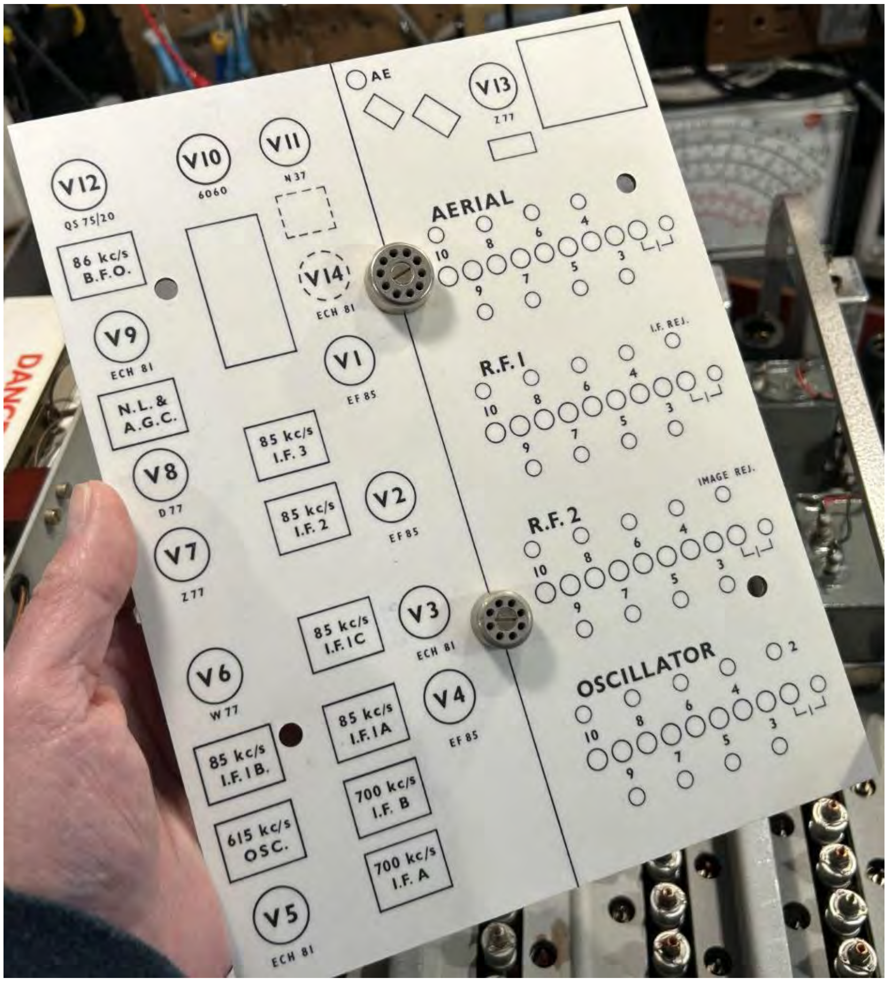


Above: two views of the reconstructed 'AGC Assembly'. Left: the circuit of the 'AGC Assembly' was first reconstructed on a breadboard to experiment with diode types and series resistors

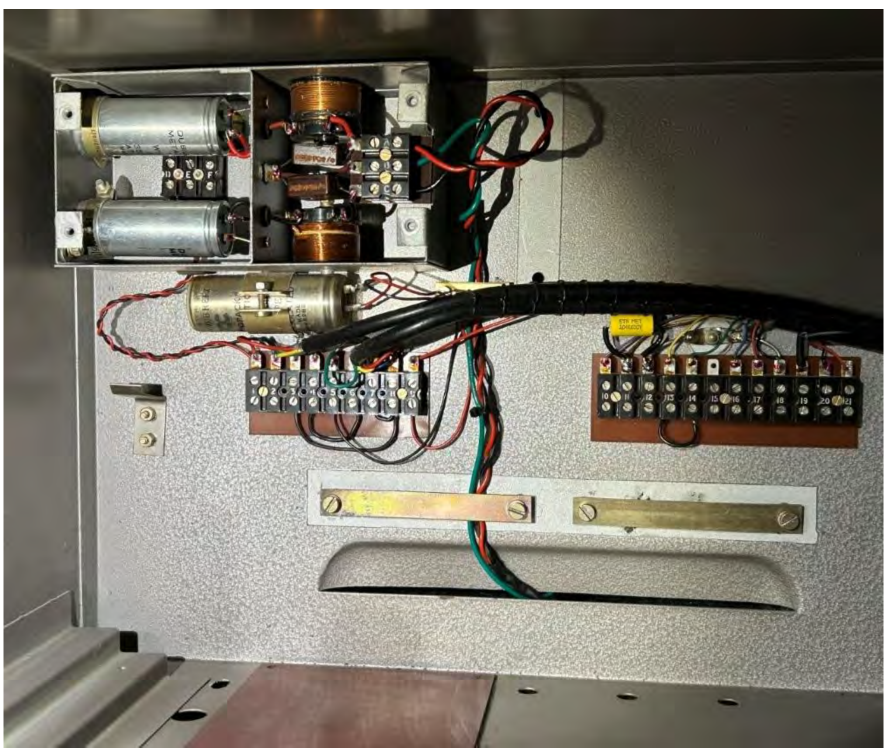


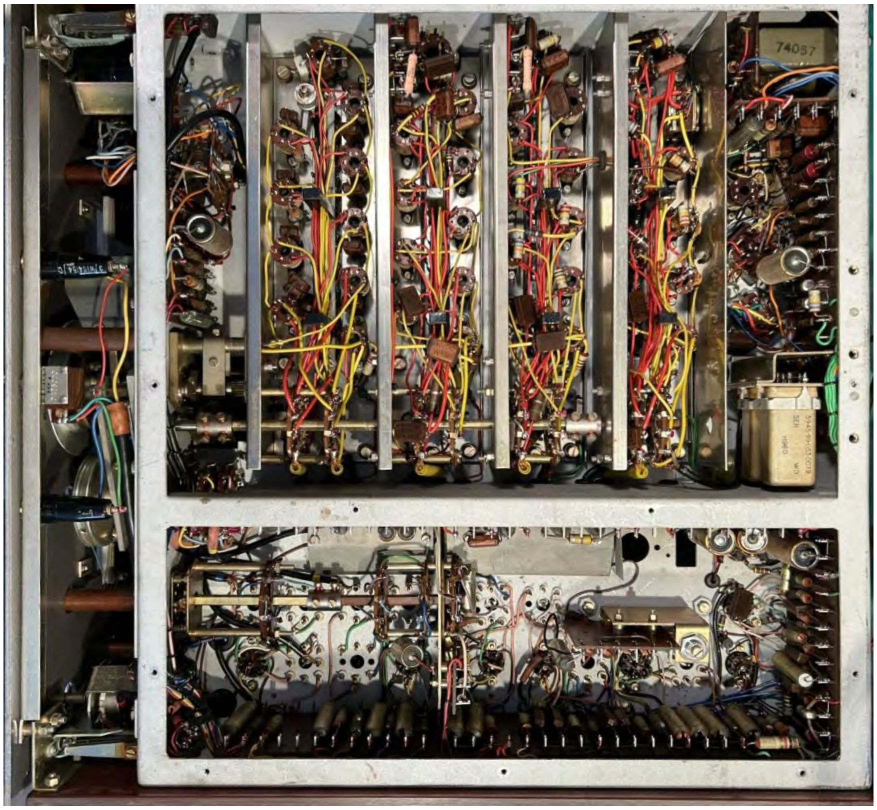
Above: the rear of the tuning gang cover looks like it should be attached to the end plate of the tuning gang – but its not(!). Left: the adjustable air-spaced temperature compensation capacitor across the 1st local oscillator section of the tuning gang. Below: the (above chassis) RF deck trimmers and slug adjuster screws – a 'twiddlers delight'…





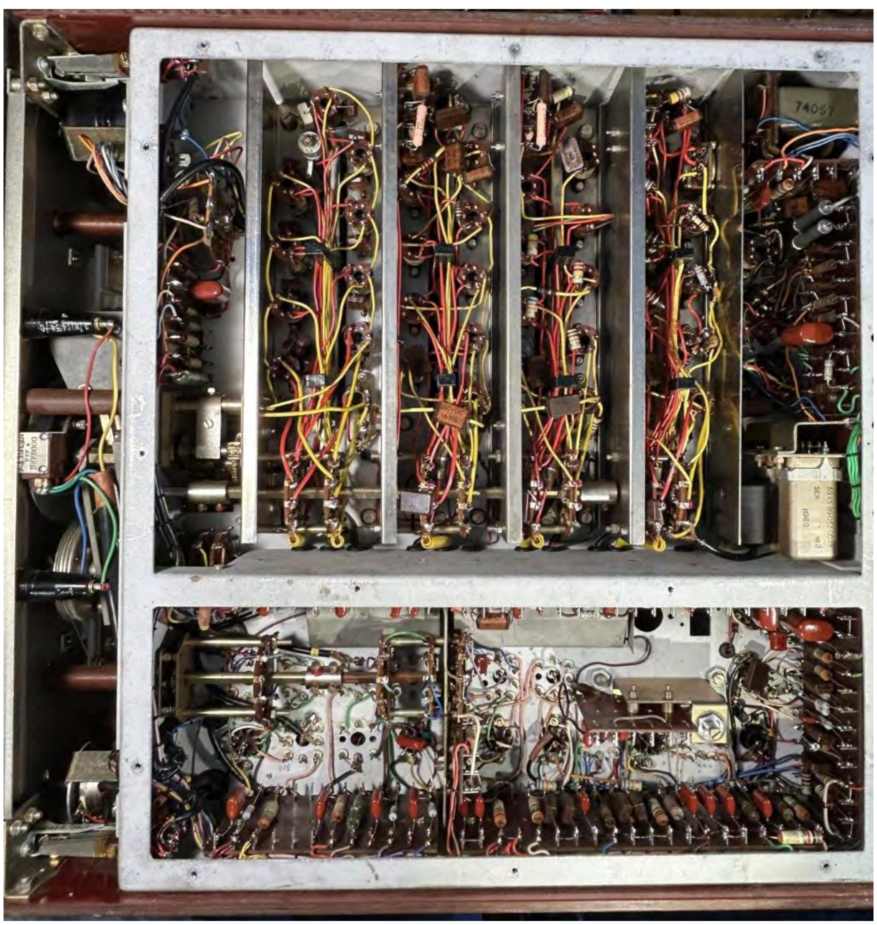
Above left: the cover for the RF deck provides a lot of useful location information. Above: all of the knobs, except the AF and RF gain controls, are screwed and keyed onto their shafts. Below left: view inside the cabinet after wiring-in the 110vDC line and filter ground wire. Below: the static discharge resistor across the antenna socket





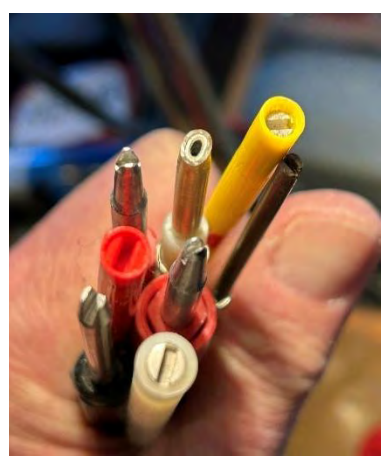
Left: underside of the chassis prior to component replacement.

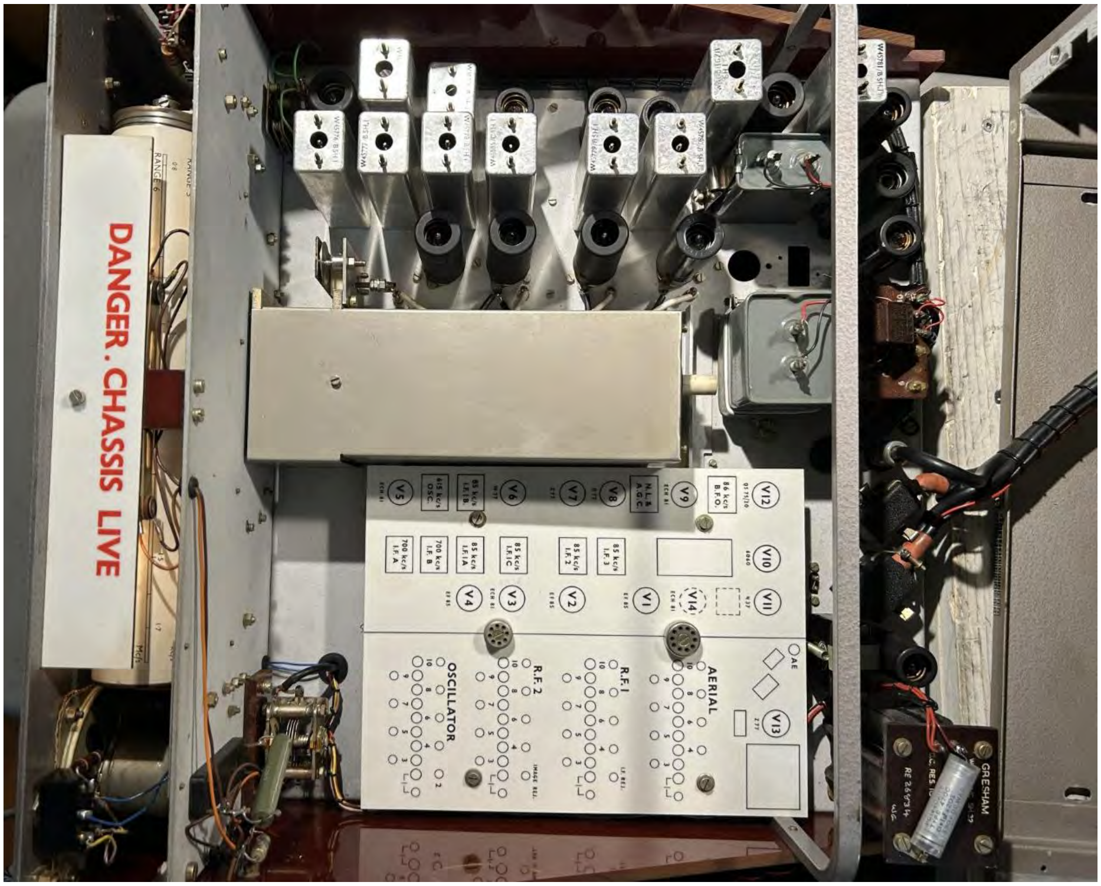
Below: close-up of the adjustment screw in one of the IF transformers (similar ones used in the RF deck) – very easily damaged if the incorrect tool is used



Right: underside of the chassis after component replacement.

Below: the ends of a selection of alignment tools – the yellow one worked very well for the slug adjustment screws





Above top side of the Atalanta chassis after refurbishing – ready to slide into its cabinet

Below: all umbilical cables connected and final checks on chassis voltages prior to installing the chassis into the cabinet

Above: checking the shape of the 85KHz IF response curves using an HP8601A/HP8600A sweeper/marker generator, displayed on a Tektronix 604 monitor (upper left quadrant of this photo)

Below: the Atalanta undergoing final soak testing prior to returning to its owner

Appendix

- Small Signal Selenium Diodes
- Thermal Images
- RF Transformer Winding Resistance Measurements
- Magnetorestrictive Filter
- Specification Data Sheet (NS. 702)
- Schematics:
    - Receiver
    - Cabinet
    - Optional Muting Circuit
    - Detailed Block Diagram
    - Simplified Circuits
    - Dial Cord Diagrams
    - Type 2202A Power Supply (as fitted to a previous Atalanta in the 'shop)
    - Homebrew Power Supply (as used on this receiver)

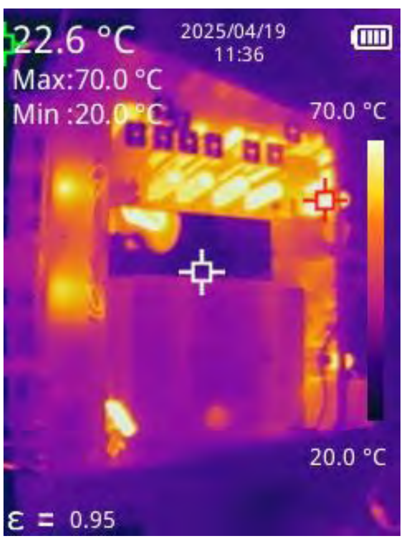
Small Signal Selenium Diodes

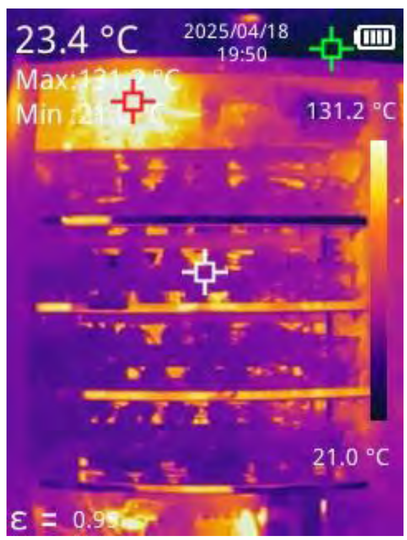
I checked the forward and reverse resistance of the six small signal selenium rectifiers after removal from the circuit – the results and comments are in the table below.

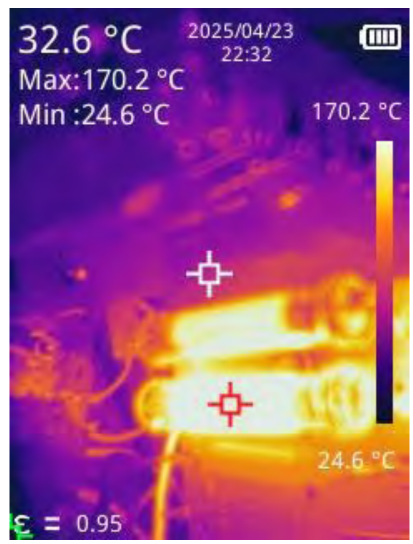
Part #	Type	Function	Forward		Reverse		Comments
			3v	30v	3v	30v	
MR1	M1	De-sense	OC	45Kohms	OC	25Mohms	Probably failing
MR2	M1	De-sense	OC	50Kohms	OC	30Mohms	Probably failing
MR3	M1	NL	35Kohms	30Kohms	OC	21Mohms	Probably ok
MR4	M1	NL	34Kohms	10Kohms	OC	10Mohms	Probably ok
MR5	M1	RF AGC	10Mohms	145Kohms	OC	OC	Failed
MR6	M1	IF AGC and NL Bias	1Mohms	95Kohms	OC	OC	Probanly failing

Measurments with a Triplett 630NA VOM on the 1Kohm (3v) and 100Kohm (30v) ranges

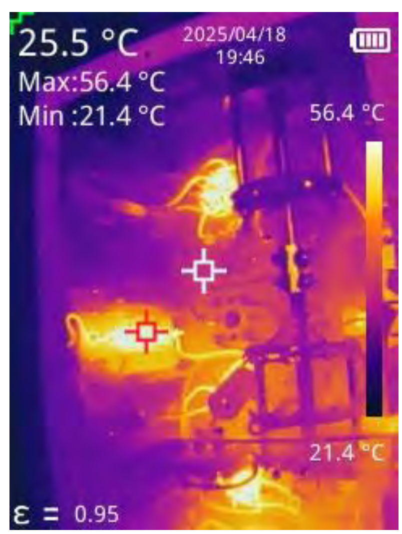
Thermal Images







Above left: above chassis thermal image after several hours operation – the hot-spot is the N37 audio output tube. Above centre: under chassis thermal image after several hours operation – the hot spot is the thermistors in the tube heater string. Above right: close-up thermal image of the two thermistors after several hours operation – they run a bit 'toasty' at up to 170C, so I spaced than apart and away from the tag board and other components. Right: Close-up of the front section of the IF section of the under-chassis – the hot spot is a 10W ceramic power resistor (R85) mounted on one of the tag boards



RF Transformer Winding Resistance Measurements

Band	Atalanta RF Transformer Winding Resistances (ohms)^						Comments
	Antenna/1st RF		1st/2nd RF Interstage		2nd RF/Mixer		
	Primary	Secondary	Primary	Secondary	Primary	Secondary	
1	5690*	1930	1.8	1840	1.3	1840	*4.7Kohm,
2	343	47500*	4720**	35700***	4.8	41.2	*47Kohm, **4.7Kohm, ***33Kohm
3	713*	76	O/C**	65	0.7	70.9	*680ohm, **1st RF stage not operational on Band 3, 1st RF stage plate disconencted, ^^1.4ohms
4	381*	36	O/C**	36	5.8	35	*330ohm, **1st RF stage not operational on Band 4, 1st RF stage plate disconencted, ^^0.8ohms
5	174*	8	O/C**	8.8	5.8	8.6	*150ohm, **1st RF stage not operational on Band 5, 1st RF stage plate disconencted, ^^0.5ohms
6	O/C*	258000**	1.4	2	0.34	1.98	*150pF cap (12.7ohms without), **secondary O/C/250Kohm damping resistor
7	230*	0.9	0.3	0.86	0.35	0.98	*220ohm
8	O/C*	0.5	1140**	0.46	1030**	0.51	*470pF cap and 27ohms (0.3ohms without), **1Kohm
9	5.1	0.23	1140*	0.2	1030*	0.27	*1Kohm
10	5.5	0.21	1140**	0.2	1030**	0.22	

^ Including band change switch contact resistance and series resistors where present (asterisked in Comments)

^^ Combined Antenna/1st RF stage transformer secondary and 1st Rf/2nd RF interstage transformer primary winding resistances (in parallel)

APPENDIX 1

Magnetrostriction

Ferromagnetic materials such as iron, nickel, cobalt and alloys of these metals undergo a change of dimensions when subject to a change of magnetic state. This effect, which is reversible, is known as the magnetostrictive effect. The change in dimensions takes place along the same line as that of the magnetic force but is normally independent of the sense of the magnetic field.

Suppose that a rod of magnetostrictive material is placed in a coil (Fig. 22) when a A.C. is applied to the coil the changes in the magnetic state will cause the rod to contract and expand in the direction of the field and hence to vibrate longitudinally.

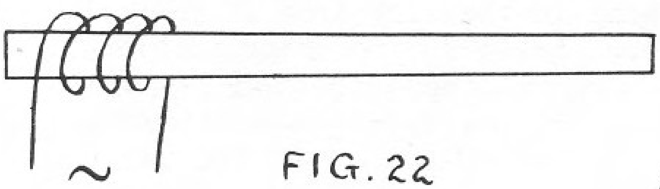


FIG. 22

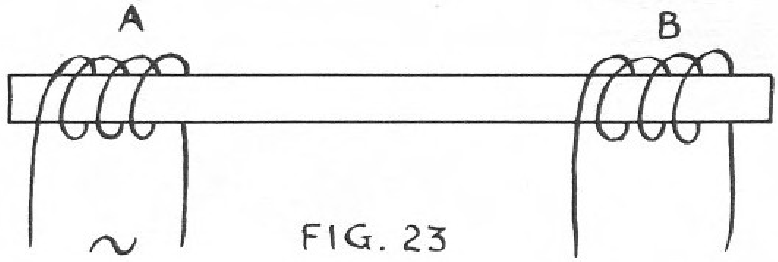


FIG. 23

If two coils are arranged as in Fig. 23 then longitudinal changes in dimension caused by an A.C. input to coil "A" will create a changing magnetic field at "B" which will induce E.M.F. into coil "B". It should be noted that, in the absence of any precautions, the frequency of the output from "B" will be twice that of the input to "A", since the changes in dimensions are independent of the sense of the magnetic field; thus a positive half cycle at the input will cause the rod to expand and then return to normal, i.e. a complete cycle of operations. The succeeding negative half cycle of the input to "A" will cause another, exactly similar cycle in the change of dimensional state of the rod. To avoid the occurrence of this effect the rod may be magnetically polarised so that the changes which are caused in its magnetic state do not set up a change in magnetic polarity but merely increase or decrease the magnitude of an unvarying polarity; the input and output frequencies will now be the same. The reader will recall that a similar subterfuge is necessary to avoid frequency doubling in the case of telephone receivers.

The magnitude of the output increases with the amplitude of the vibrations. The changes in length are normally of the order of thirty parts in a million but when the rod is made resonant they increase considerably and become about one part in one thousand; for this reason bars one half wavelength long are commonly employed; the calculation being based on the velocity of sound in the material - about 5000 metres per second.

Since $\lambda = \frac{v}{f}$: the length of the rod is $\frac{\lambda}{2} = \frac{5000}{2f}$ metres.

For the "Atalanta" receiver, f = 85 kc/s so that the length of rod is about 0.03 metres, i.e. approximately 3 cms.

If D.C. is passed along the rod while A.C. is applied to the coil "A", Fig. 23, the resultant magnetic field will be a combination of the circular field set up by the D.C. and the longitudinal field due to the coil and, in fact, takes the form of a helical field. The rod expands and contracts in the direction of the helical lines of force and is, therefore, twisted, producing torsional vibrations. In this case the output and input frequencies will always be the same, since the necessary polarisation is effected by the D.C. flowing along the rod. Alternatively, the rod may be permanently magnetised by initially passing a large direct current through it or in cases in which the ohmic resistance of the rod is very large, by passing the direct current through a wire running down the centre of the rod, this being the only practical way of providing the necessary polarisation. An advantage of using a high resistance rod is that eddy current losses are very considerably reduced.

The form of the filter used in the "Atalanta" receiver is shown in Fig.25; the wire shown runs through the centre of the rod and after the initial magnetisation has been effected is of no further use and is connected to the receiver chassis. Owing to the short length of the rod, unwanted mutual coupling exists between the two coils; the effect of this would be deleterious to the action of the device so it is cancelled by feeding into the output circuit an E.M.F. equal, but in opposite phase, to the E.M.F. due to mutual coupling.

In the "Atalanta" receiver the filter is located between V5 and V6 and appears in Fig.1 and in the circuit diagram in the manufacturers manual in the form shown in Fig.24.

The bandwidth obtained in this circuit is about 100 c/s. From a well known relationship the approximate effective circuit Q may be calculated:

$$Q = \frac{fo}{\Delta f} = \frac{85\ 000}{100} = 850$$

fo being the resonant frequency, 85 kc/s in this case, and
Δ f the bandwidth between voltage points which are $\sqrt{2}$ times down from the maximum.

It is instructive and interesting to apply to coil "A", in

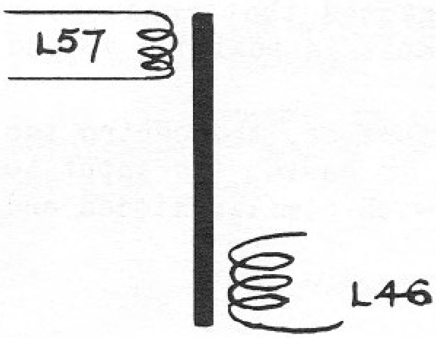


FIG. 24

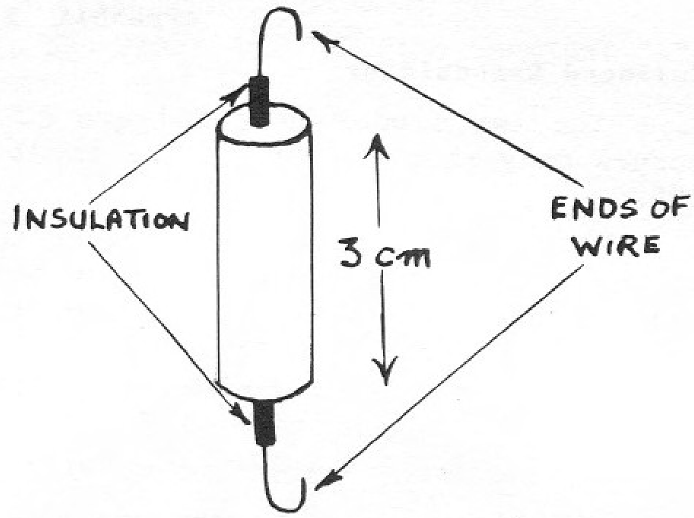


FIG. 25

the "Atalanta" receiver, the output from a signal generator tunable in frequency around 85 kc/s and to observe the output voltage from coil "B" on an oscilloscope. A noteworthy increase in the amplitude of the output takes place as the signal generator is tuned through resonance. If a wobbulator is employed the extreme sharpness of the response curve can be seen.

Magnetostrictive bars constitute a very convenient way of obtaining these high effective "Q" values for frequencies between about 5 kc/s and 100 kc/s; outside this range the size of bar is either too large or too small for convenient practical use.

Marconi General-purpose Receiver Type NS 702

The Marine Receiver Type NS 702 complies with the latest international regulations and the British G.P.O performance specification for a general-purpose receiver for ships. It is particularly suitable for mobile, maritime or fixed stations having to receive signals from a wide range of transmitting sources. It is designed to operate with an external loudspeaker. Provision is also made for the addition of an internal loudspeaker, and for switch selection between internal and external loudspeakers.

The receiver is normally enclosed in a metal cabinet suitable for bench-mounting.

FEATURES

Band-spread scales, directly calibrated in frequency, are provided for the six selected bands and in addition electrical fine tuning within ±3 kHz is provided on all frequencies above 800 kHz and in the range 25–100 kHz.

Built-in crystal oscillator facilitates checking of frequency calibration and precise setting of bandspread scales.

Incorporates pulse-noise limiting circuits.

Four degrees of selectivity, the narrowest achieved by a magneto-striction filter operating at i.f.

Stabilized voltage supplies and temperature compensating elements give a high degree of stability.

Desensitizing facilities included.

Receiver can operate directly from d.c mains of 110 V with no vibrating or rotating voltage-converting equipment.

Circuit

The Type NS 702 has two stages of signal frequency amplification preceding the triode-heptode frequency changer. Two stages of intermediate frequency amplification at 85 kHz follow the frequency changer when signals in the bands 15–25 and 100–800 kHz are being received. When operating on frequencies above 800 kHz, however, and also in the band 25–100 kHz, the double superheterodyne principle is followed in order to secure the maximum image frequency protection. The frequency changer then gives a first i.f of 700 kHz and an i.f filter tuned to this frequency is switched into use. This is followed by a further triode-heptode frequency changer, giving a second i.f of 85 kHz, and two stages of amplification at that frequency. The final i.f tuned circuit is followed by a double-diode valve which functions as a balanced demodulator on c.w reception; one diode only is used on m.c.w. Two stages of a.f amplification are followed by an output stage.

An internal 700 kHz crystal oscillator is provided for setting up the band-spread scale and for frequency checking purposes.

6639

DATA SUMMARY

Frequency range: 15 kHz 28 MHz, continuous coverage in ten ranges.

Outputs:

(a) 1 W into external or internal (or both) loudspeakers.

(b) 10 mW into low impedance headphones.

(c) Output suitable for telephone handset (15 Ω impedance).

Input: Suitable for aerials of total capacitance (including feeder) up to 600 pF. Above 4 MHz, 75 Ω unbalanced.

Selectivity: i.f. bandwidths of 8 kHz, 3 kHz, 1000 Hz and 100 Hz at 6 dB attenuation can be switch-selected.

Sensitivity: Input required for 20 dB signal-to-noise ratio, c.w conditions:

	Bandwidth Hz	*Dummy Aerial*	*Input* μV
15–160 kHz	1000	300 pF	6–20
160–1500 kHz	3000	300 pF	4–10
1500–4000 kHz	8000	300 pF	2·5–3·5
4–15 MHz	8000	75 Ω	1·5–2·5
15–28 MHz	8000	75 Ω	2–3

Image protection: Better than
85 dB from 15 kHz to 3 MHz.
65 dB from 3 to 7·5 MHz.
46 dB from 7·5 to 15 MHz.
30 dB from 15 to 28 MHz.

A.G.C: Not more than 8 dB change in output for 60 dB change in input.

Power supply: 110 V d.c mains supply Additional supply units are available to permit operation from 220 V d.c, 115 V or 230 V a.c, or from 24 V d.c supplies. The a.c mains power unit fits into the receiver cabinet.

Dimensions:

Height	$12\frac{9}{16}$ in.	(32 cm)
Width	$19\frac{1}{2}$ in.	(49·5 cm)
Depth	$19\frac{13}{16}$ in.	(50·3 cm)
Weight	78 lb*	(35·5 kg)

** 84 lb (38 kg) with a.c power unit.*

THE MARCONI COMPANY LIMITED
Radio Communications Division

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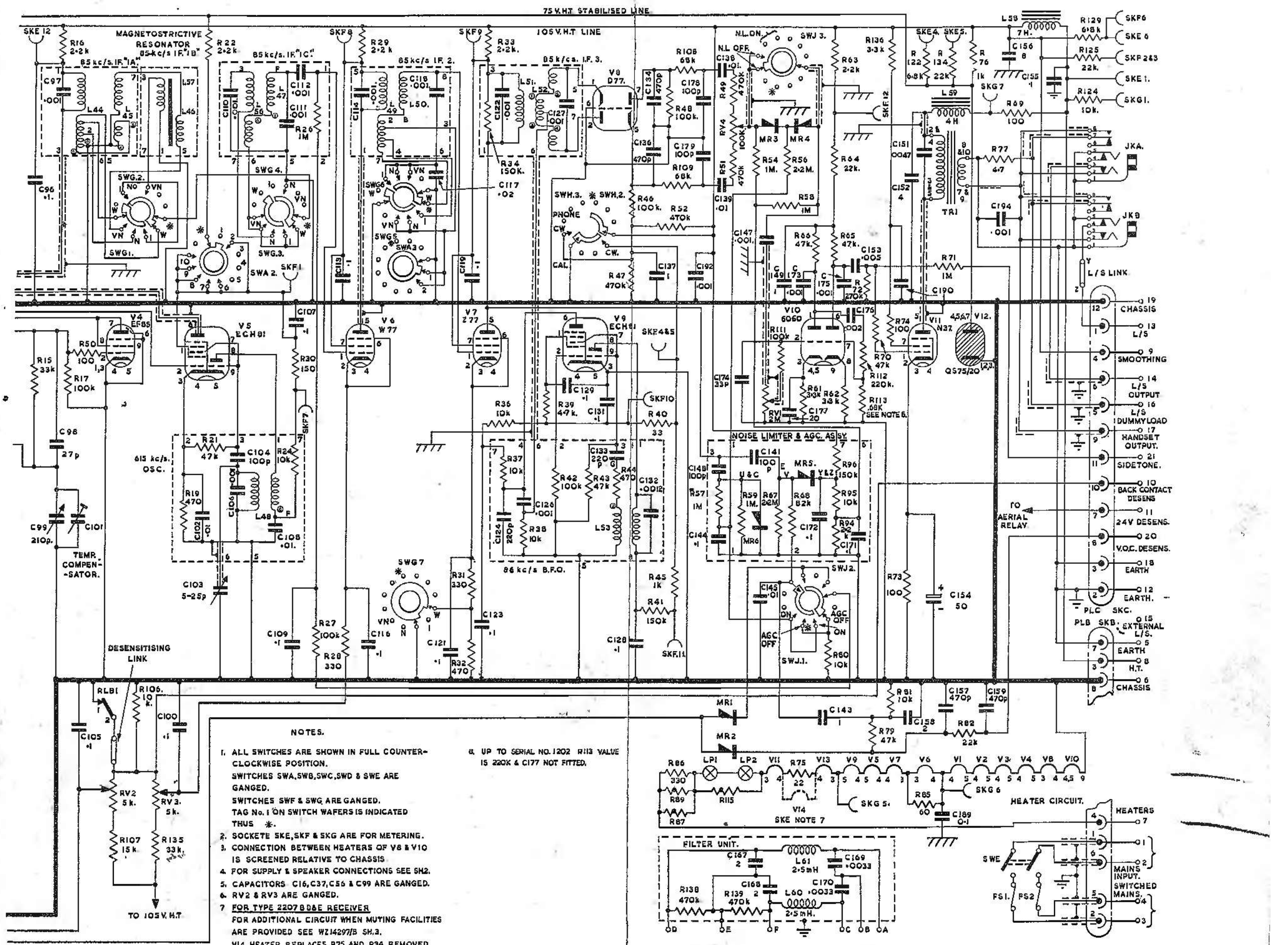


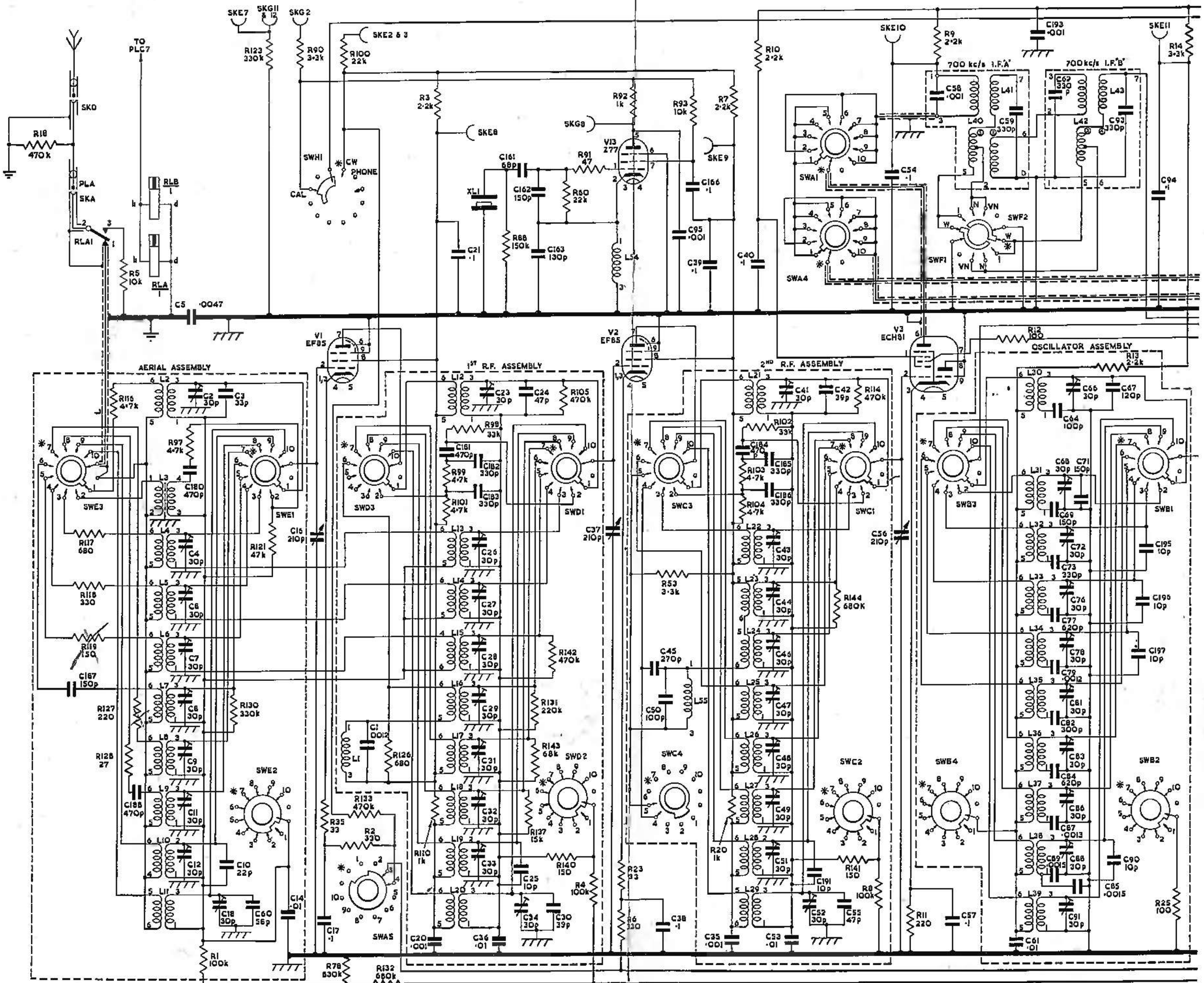
NOTES.

1. ALL SWITCHES ARE SHOWN IN FULL COUNTER-CLOCKWISE POSITION.
   SWITCHES SWA, SWB, SWC, SWD & SWE ARE GANGED.
   SWITCHES SWF & SWG ARE GANGED.
   TAG No. 1 ON SWITCH WAFERS IS INDICATED THUS *.
2. SOCKETS SKE, SKF & SKG ARE FOR METERING.
3. CONNECTION BETWEEN HEATERS OF V8 & V10 IS SCREENED RELATIVE TO CHASSIS.
4. FOR SUPPLY & SPEAKER CONNECTIONS SEE SH2.
5. CAPACITORS C16, C37, C56 & C99 ARE GANGED.
6. RV2 & RV3 ARE GANGED.
7. FOR TYPE 2207 B D & E RECEIVER
   FOR ADDITIONAL CIRCUIT WHEN MUTING FACILITIES ARE PROVIDED SEE WZ14297/B SH.3.
   V14 HEATER REPLACES R75 AND R34 REMOVED.
8. UP TO SERIAL NO. 1202 R113 VALUE IS 220K & C177 NOT FITTED.

Issue No. 7
Sheet No. 2

W.50259

CIRCUIT DIAGRAM "ATALANTA" RECEIVER TYPE 2207C (PART 2)



Issue No. 4
Sheet No. 1

W.50259

CIRCUIT DIAGRAM "ATALANTA" RECEIVER TYPE 2207C (PART 1)

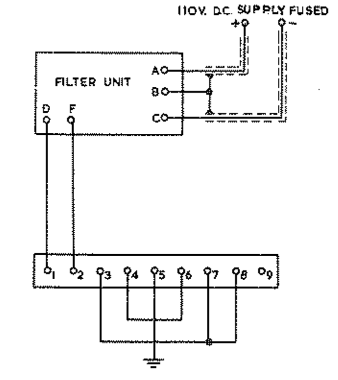


FIG. 1 110V D.C.

NOTES.

1. SUPPLY LEAD CLAMPS ARE SUITABLE FOR 3/·029" SINGLE LEAD COVERED CABLE OR FLAT 3/·029" TWIN LEAD COVERED OF SIMILAR THICKNESS.
2. SUPPLY LEAD SCREENING MUST BE CARRIED INTO FILTER BOX.
3. CASE EARTH BOLT MUST BE CONNECTED DIRECT TO EARTH USING COPPER STRIP.
4. TWO FUSES OF 1 AMP. RATING ARE FITTED.
5. LINKS ARE CONNECTED TO TERMINAL BLOCKS AS SHOWN.

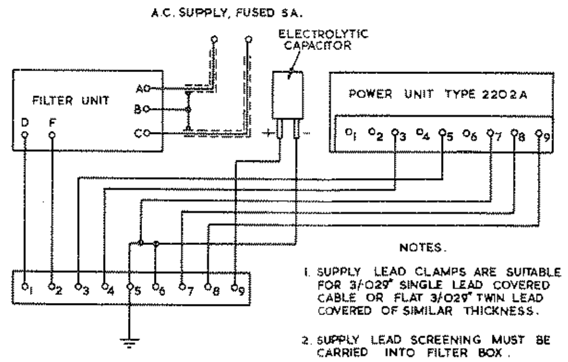


FIG.2 230 OR 115V A.C.

NOTES.

1. SUPPLY LEAD CLAMPS ARE SUITABLE FOR 3/·029" SINGLE LEAD COVERED CABLE OR FLAT 3/·029" TWIN LEAD COVERED OF SIMILAR THICKNESS.
2. SUPPLY LEAD SCREENING MUST BE CARRIED INTO FILTER BOX.
3. CASE EARTH BOLT MUST BE CONNECTED DIRECT TO EARTH USING COPPER STRIP.
4. TWO FUSES OF 1 AMP. RATING ARE FITTED.
5. PROVISION IS MADE FOR THE A.C. POWER UNIT TYPE 2202A TO BE MOUNTED IN THE REAR OF THE RECEIVER CABINET.
6. TRANSFORMER PRIMARY TAPS ARE ADJUSTED TO SUIT SUPPLY VOLTAGE BEFORE FITTING.
7. THE 32μF ELECTROLYTIC CAPACITOR SUPPLIED WITH THE POWER UNIT MUST ALSO BE MOUNTED IN THE REAR OF THE CASE ABOVE THE TERMINAL BLOCK.
8. CONNECTIONS FROM TERMINAL BLOCK TO POWER UNIT & CAPACITOR SHOULD BE MADE WITH LEADS PROVIDED. LINKS TO BE ARRANGED AS SHOWN.

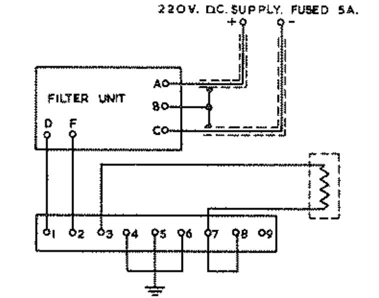


FIG. 3a 220V D.C.

NOTES.

1. SUPPLY LEAD CLAMPS ARE SUITABLE FOR 3/·029" SINGLE LEAD COVERED CABLE OR FLAT 3/·029" TWIN LEAD COVERED OF SIMILAR THICKNESS.
2. SUPPLY LEAD SCREENING MUST BE CARRIED INTO FILTER BOX.
3. CASE EARTH BOLT MUST BE CONNECTED DIRECT TO EARTH USING COPPER STRIP.
4. TWO FUSES OF 1 AMP. RATING ARE FITTED.
5. WHEN THE DROPPING RESISTOR (B.E.R.Co. 260Ω VGHK5 IN COVER SA 69) IS MOUNTED ON THE REAR OF RECEIVER CASE, THE CONNECTIONS & LINKS TO TERMINAL BLOCK ARE AS SHOWN IN FIG.3a.
6. WHEN RESISTOR UNIT IS MOUNTED REMOTELY, CONNECTIONS & LINKS ARE AS SHOWN IN FIG.3b. A JUNCTION BOX WILL BE NECESSARY IF TWIN CABLE IS EMPLOYED.

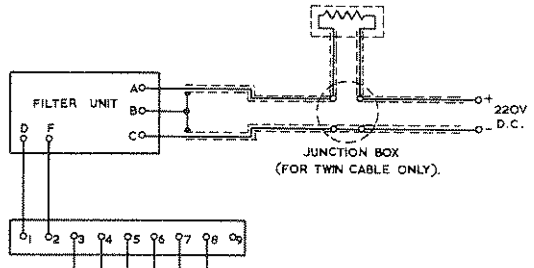


FIG.3b 220V D.C.

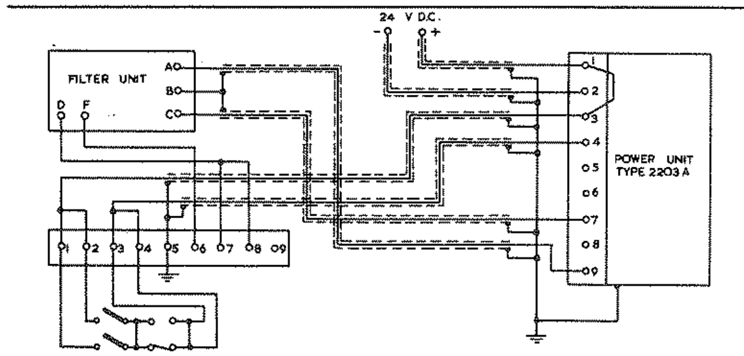
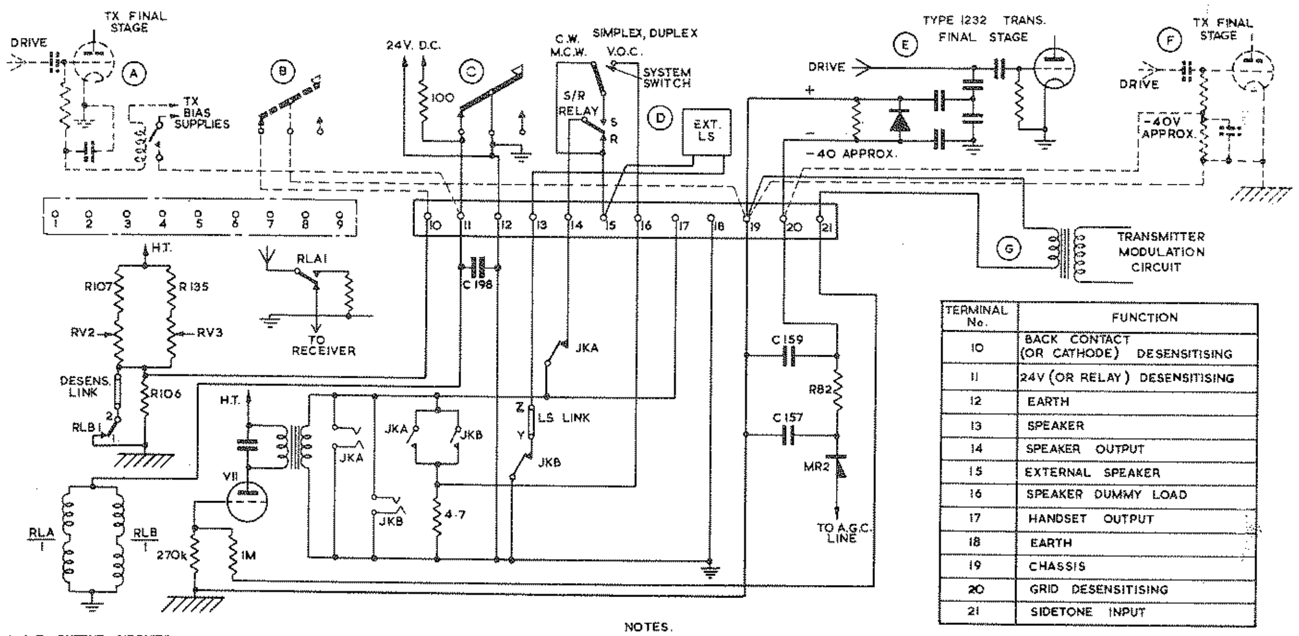


FIG. 4 24V D.C.

NOTES.

1. ALL LEADS ENTERING OR LEAVING THE RECEIVER CASE MUST BE SCREENED OR LEAD COVERED, WITH THE SCREENING CARRIED INSIDE THE CASE AS FAR AS POSSIBLE & SECURELY BONDED.
2. THE SCREENING OF THE 110V. SUPPLY LINE FROM THE POWER UNIT TYPE 2203A MUST BE CARRIED INTO THE FILTER BOX.
3. CASE EARTH BOLT MUST BE CONNECTED DIRECT TO EARTH USING COPPER STRIP.
4. THE 24V SUPPLY LEADS MUST BE KEPT AS SHORT AS POSSIBLE (WITH 3/·029" THE TOTAL LOOP LENGTH MUST NOT EXCEED 20 FT.). THE VOLTAGE DROP IN THESE LEADS MUST NOT EXCEED 0·5V.
5. IN ORDER TO REDUCE VOLTAGE DROP IN THE RECEIVER WIRING, THE INTERNAL LEADS ARE PARALLELED. THIS INVOLVES THE PARALLEL CONNECTION OF THE TWO FUSEHOLDERS, END CONTACT TO END CONTACT, SIDE CONTACT TO SIDE CONTACT, WITH SHORT LINKS OF 14/·0076" FLEXIBLE CABLE; OR BY TRANSFERRING THE CONNECTIONS FROM THE RIGHT HAND FUSEHOLDER TO THE LEFT HAND FUSEHOLDER (END CONNECTION TO END CONNECTION, SIDE CONNECTION TO SIDE CONNECTION). THE TWO 1AMP. FUSES ARE THEN WITHDRAWN & REPLACED BY A SINGLE 7·5 AMP FUSE, FITTED IN THE LEFT HAND FUSEHOLDER.



TERMINAL No.	FUNCTION
10	BACK CONTACT (OR CATHODE) DESENSITISING
11	24V (OR RELAY) DESENSITISING
12	EARTH
13	SPEAKER
14	SPEAKER OUTPUT
15	EXTERNAL SPEAKER
16	SPEAKER DUMMY LOAD
17	HANDSET OUTPUT
18	EARTH
19	CHASSIS
20	GRID DESENSITISING
21	SIDETONE INPUT

1. A.F. OUTPUT CIRCUITS.

1·1 HEADPHONE OUTPUT ONLY.
- 1·1·1 LINK 16 & 17.
- 1·1·2 L.R. (600Ω) 'PHONES INSERTED INTO EITHER FRONT PANEL JACK.
- 1·1·3 EXTERNAL L.R. 'PHONES CONNECTED BETWEEN 17 & 18.

1·2 HANDSET OUTPUT ONLY.
- 1·2·1 LINK 16 & 17.
- 1·2·2 CONNECT HANDSET BETWEEN 17 & 18.
- 1·2·3 IF ATTENUATION OF HANDSET SIGNAL IS NECESSARY, A SERIES RESISTOR SHOULD BE USED.

1·3 EXTERNAL LOUDSPEAKER – DIRECT CONNECTION.
- 1·3·1 CONNECT LOUDSPEAKER (5Ω) BETWEEN 17 & 18.
- 1·3·2 ALL A.F. SWITCHING IS NOW INOPERATIVE.
- 1·3·3 INSERTION OF 'PHONES REDUCES OUTPUT BY 3db.

1·4 EXTERNAL LOUDSPEAKER – JACK SWITCHING.
- 1·4·1 LINK Y & Z ON SPEAKER CONNECTION TAGBOARD (MOUNTED BELOW CHASSIS).
- 1·4·2 LINK 14 & 15.
- 1·4·3 CONNECT LOUDSPEAKER (5Ω) BETWEEN 13 & 15.

1·5 EXTERNAL LOUDSPEAKER – JACK & TRANSMITTER SWITCHING.
- 1·5·1 LINK Y & Z ON SPEAKER CONNECTION TAGBOARD.
- 1·5·2 CONNECT LOUDSPEAKER BETWEEN 13 & 15.
- 1·5·3 CONNECT TRANSMITTER LINES AS SHOWN AT "D" (SYSTEM SHOWN IS FOR TYPE 1232 TRANSMITTER & IS TYPICAL).

1·6 INTERNAL LOUDSPEAKER – JACK SWITCHING.
- 1·6·1 CONNECT INTERNAL LOUDSPEAKER TO Y & Z ON SPEAKER CONNECTION TAGBOARD.
- 1·6·2 LINK 13 & 14.

1·7 INTERNAL LOUDSPEAKER – JACK & TRANSMITTER SWITCHING.
- 1·7·1 CONNECT INTERNAL LOUDSPEAKER TO Y & Z ON SPEAKER CONNECTION TAGBOARD.
- 1·7·2 LINK 13 & 15.
- 1·7·3 CONNECT TRANSMITTER LINES AS SHOWN AT "D" (SYSTEM SHOWN IS FOR TYPE 1232 TRANSMITTER & IS TYPICAL).

NOTES.

2. DESENSITISING.

2·1 RELAY DESENSITISING & AERIAL PROTECTION
- 2·1·1 IF A KEYING RELAY MAKE CONTACT IS AVAILABLE, 24 V D.C. MAY BE APPLIED THROUGH THIS DIRECTLY TO TERMINALS 11 & 12 (EARTH).
- 2·1·2 WHERE ONLY THE KEY IS AVAILABLE, THE BACK CONTACT MAY BE UTILISED AS SHOWN AT "C" TO APPLY 24V D.C.
- 2·1·3 WITH TYPE 1232 OR SIMILAR TRANSMITTERS, THE FINAL STAGE GRID CURRENT IS USED TO OPERATE A RELAY AS AT "A", THIS RELAY OPERATING RLA & RLB FROM THE TX BIAS SUPPLIES; A 24V D.C. SUPPLY IS NOT REQUIRED.

2·2 CATHODE DESENSITISING.
- 2·2·1 THE BACK CONTACTS OF THE KEY ARE CONNECTED AS AT 'B', THE DESENSITISING LINK BEING DISCONNECTED.
- 2·2·2 WITH THIS SYSTEM CHASSIS & KEY ARE BONDED SO THAT:–
  - 2·2·2·1 THE CHASSIS MUST BE EARTHED, OR
  - 2·2·2·2 THE KEY MUST BE ISOLATED FROM EARTH.

2·3 GRID DESENSITISING (SEE NOTE 4).
- 2·3·1 A NEGATIVE VOLTAGE OF 40–50 VOLTS IS APPLIED TO THE A.G.C LINE VIA TERMINAL 20. THIS MAY BE DERIVED FROM THE FINAL STAGE GRID AS AT "F", WHERE THE RECEIVER CHASSIS IS CONNECTED TO TRANSMITTER CHASSIS.
- 2·3·2 WHERE RECEIVER CHASSIS & TRANSMITTER CHASSIS MAY NOT BE LINKED, THE CIRCUIT USED ON TYPE 1232 TRANSMITTER (SHOWN AT "E") MUST BE USED.

3. SIDETONE (SEE NOTE 4).
- 3·1 SIDETONE IS TAKEN FROM A TRANSFORMER WINDING IN THE TRANSMITTER MODULATOR CHAIN AS AT "G" & APPLIED TO TERMINALS 21 & 19 (CHASSIS) AT AN APPROPRIATE LEVEL (APPROX 15V R.M.S.)

4. CONNECTIONS FOR GRID DESENSITISING & SIDETONE.
- 4·1 WHEN OPERATING WITH FLOATING CHASSIS, IT IS NECESSARY, TO MINIMISE NOISE PICK-UP, THAT THESE LEADS SHOULD BE RUN IN DOUBLE SCREENED CABLE, THE INNER SCREEN CONNECTED TO CHASSIS, THE OUTER SCREEN TO EARTH.

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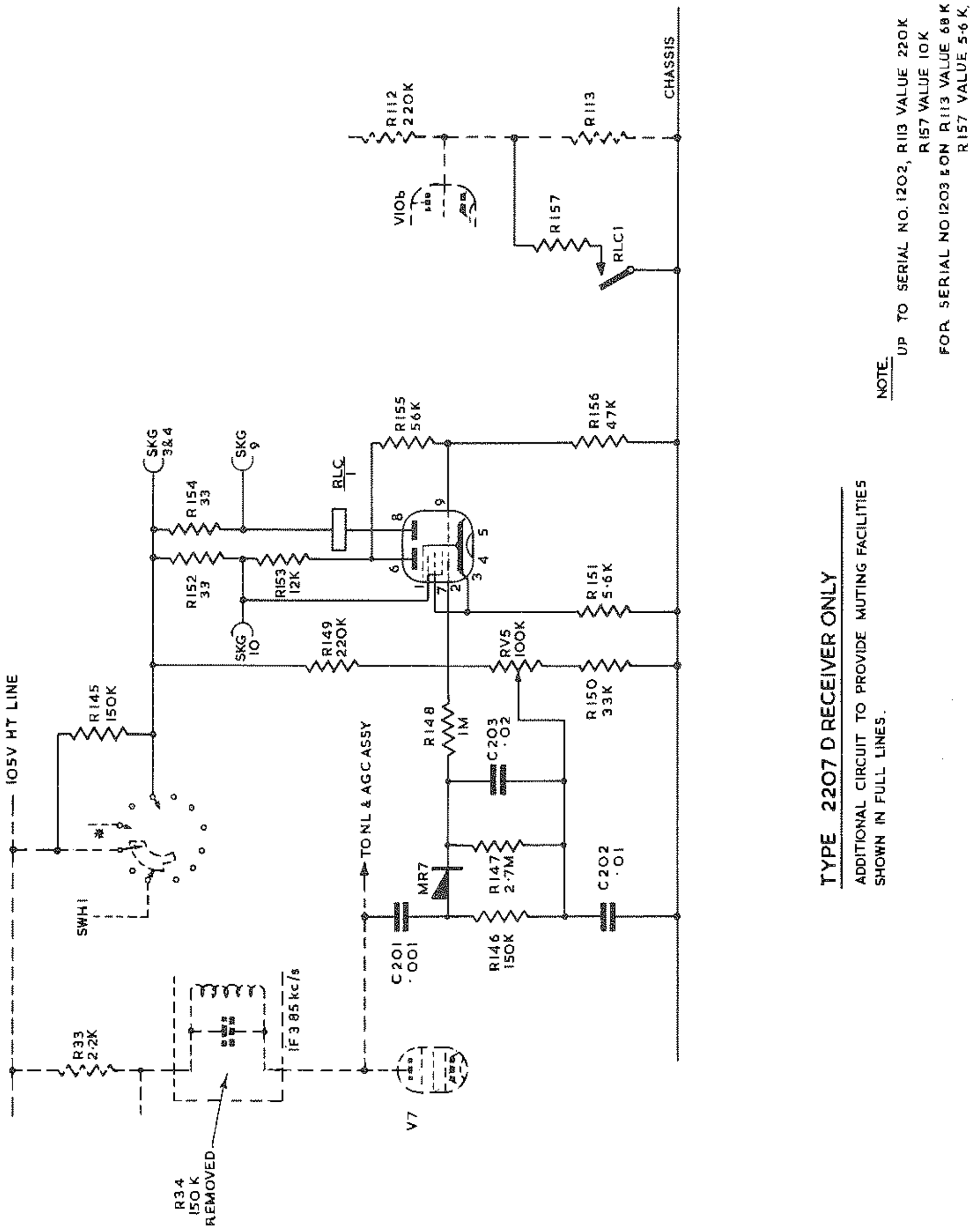
WZ.14297/D

CIRCUIT DIAGRAM "ATALANTA" RECEIVER TYPE 2207C



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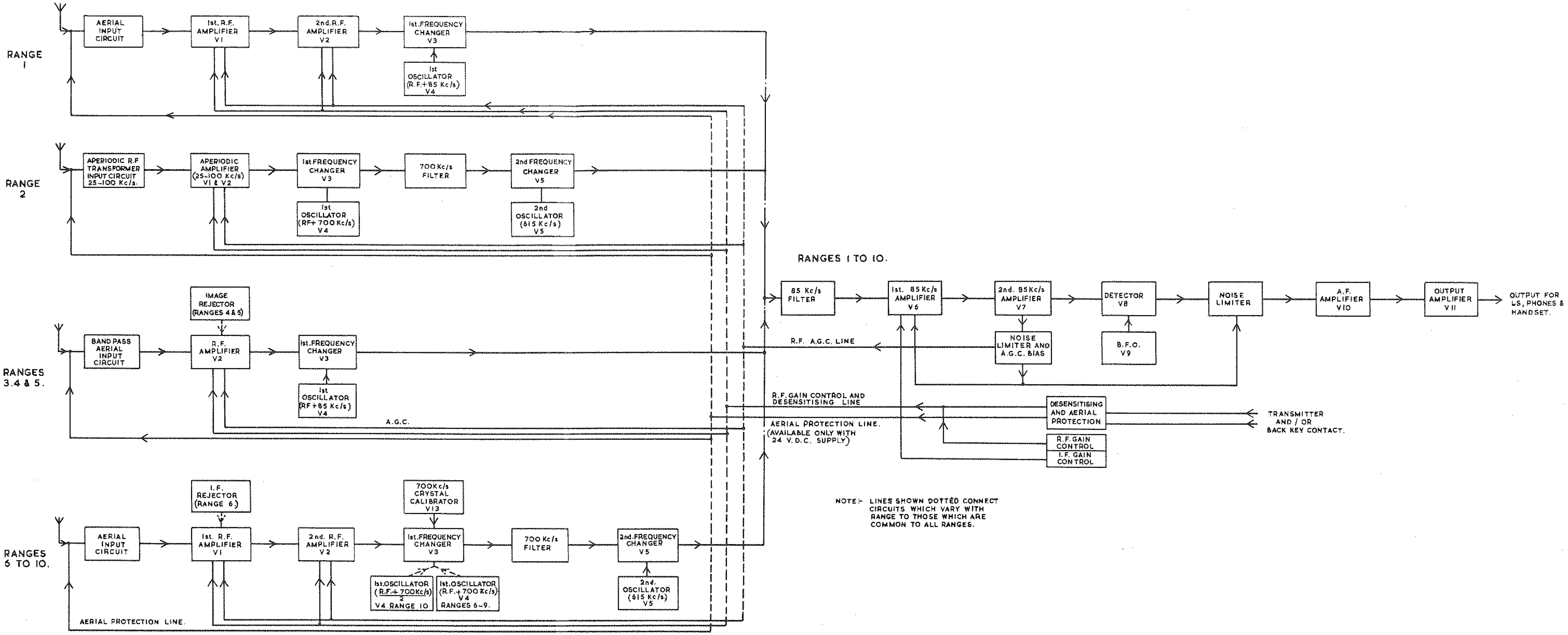
WZ.14297/B

CIRCUIT DIAGRAM "ATALANTA" RECEIVER
(ADDITIONAL CIRCUIT FOR MUTING)



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WZ.18293/D

BLOCK SCHEMATIC "ATALANTA" RECEIVER TYPE 2207C

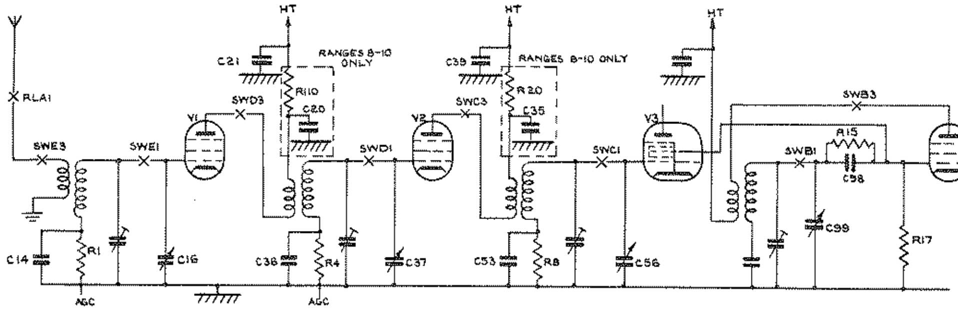

DIAGRAM A. RF AMPLIFIER, RANGES 1 & 6–10. AND 1ST OSCILLATOR, RANGES 1–10.

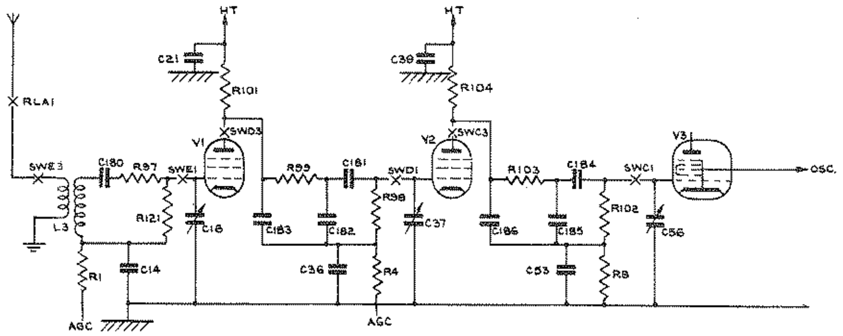

DIAGRAM B. RF. AMPLIFIER, RANGE 2.

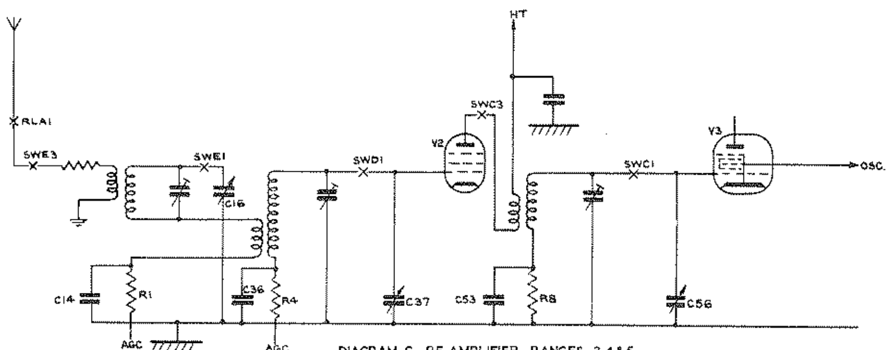

DIAGRAM C. RF AMPLIFIER, RANGES 3,4 & 5.

FIG. 1. RF AMPLIFIER & 1ST OSCILLATOR SIMPLIFIED CIRCUITS.

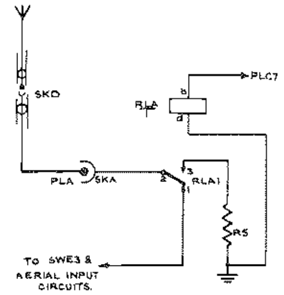

FIG. 2. AERIAL CIRCUIT PROTECTION.
(ONLY AVAILABLE WHEN 24V. DC.IS APPLIED)

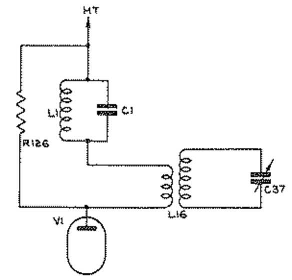

FIG. 4. RANGE 6 IF REJECTOR.

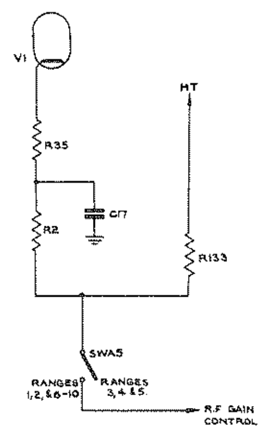

FIG. 3. V1 CATHODE VOLTAGE SWITCHING.

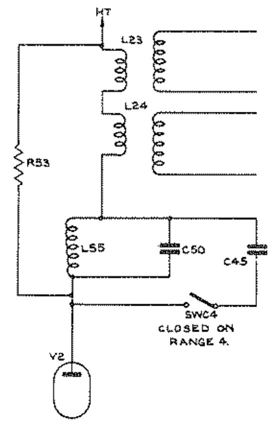

FIG. 5. RANGES 4 & 5 IMAGE REJECTOR.

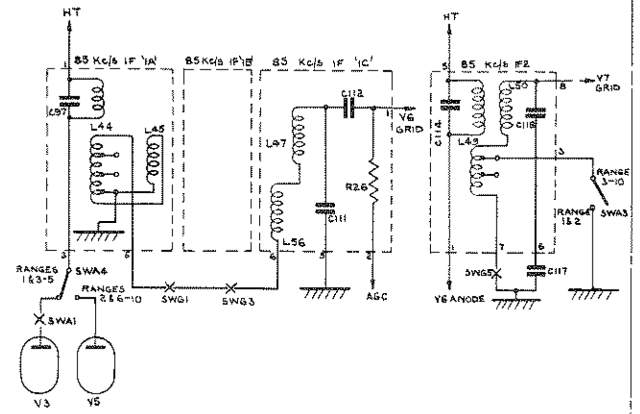

DIAGRAM A. WIDE PASSBAND.

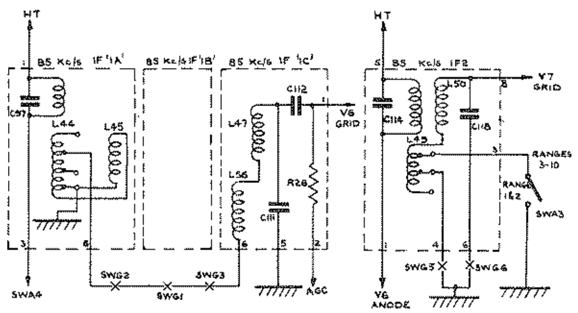

DIAGRAM B. INTERMEDIATE PASSBAND.

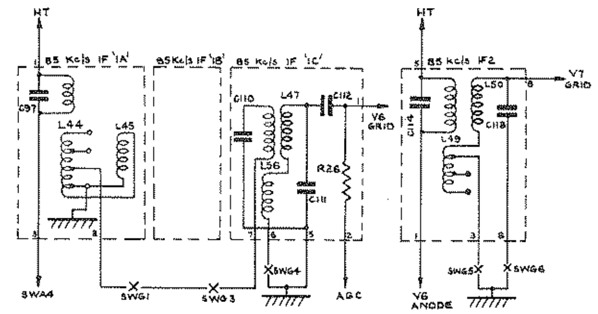

DIAGRAM C. NARROW PASSBAND.

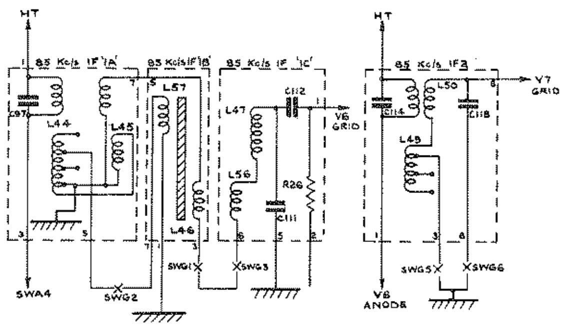

DIAGRAM D. VERY NARROW PASSBAND.

FIG. 6. 85 KC/S IF CIRCUITS.
(WIDE, INTERMEDIATE, NARROW AND VERY NARROW POSITIONS OF PASSBAND SWITCH.)

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SIMPLIFIED CIRCUITS "ATALANTA" RECEIVER TYPE 2207C

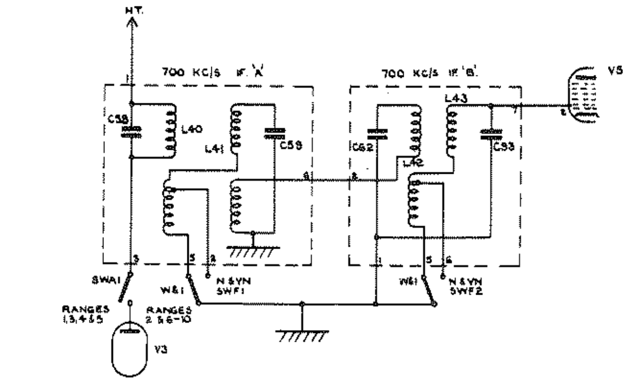


FIG. 7. 700 KC/S IF CIRCUITS.
(WIDE & INTERMEDIATE PASSBAND.)

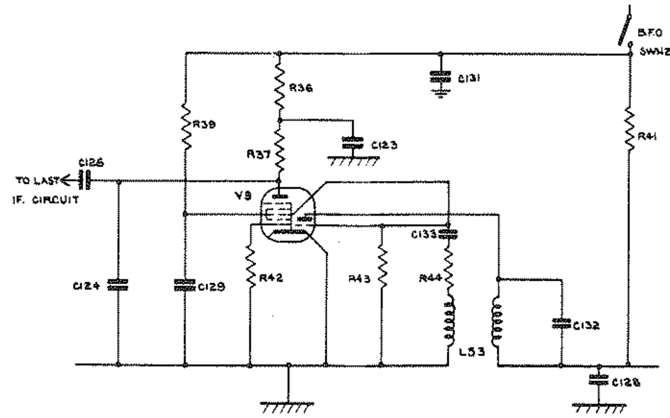


FIG. 9. B.F.O. CIRCUITS.
(TRIODE OSC & HEPTODE BUFFER)

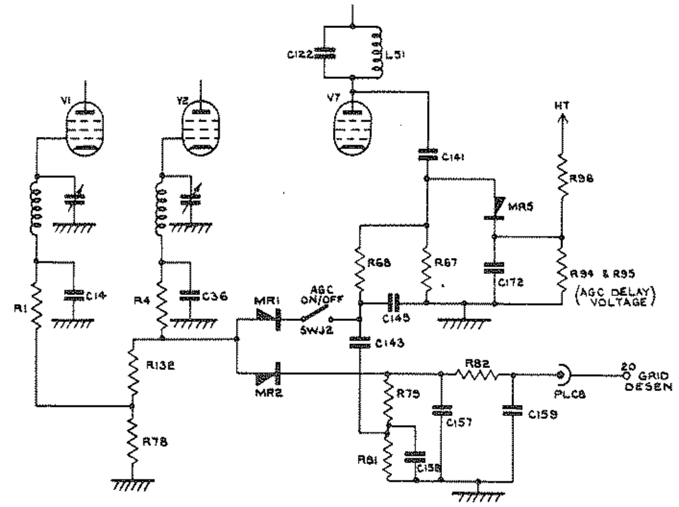


FIG. 11. GRID DESENSITISING & RF VALVES AGC SYSTEM.

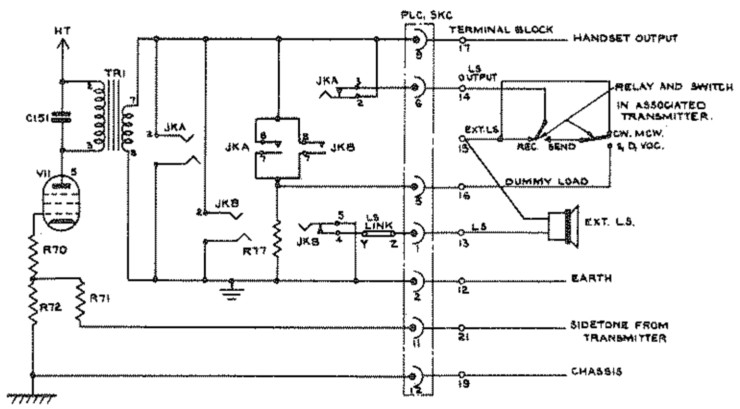


FIG 13. AF OUTPUT & SIDETONE CIRCUITS.

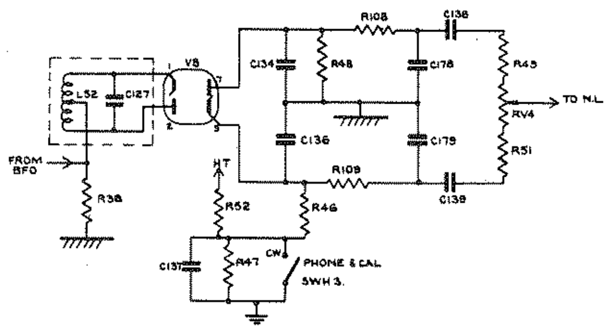


FIG 8. DETECTOR

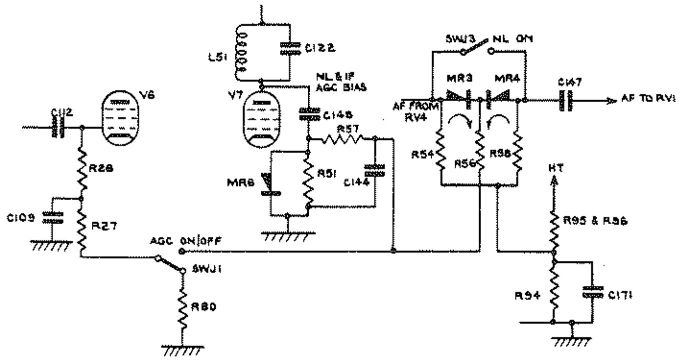


FIG. 10. NL & IF AGC CIRCUITS.

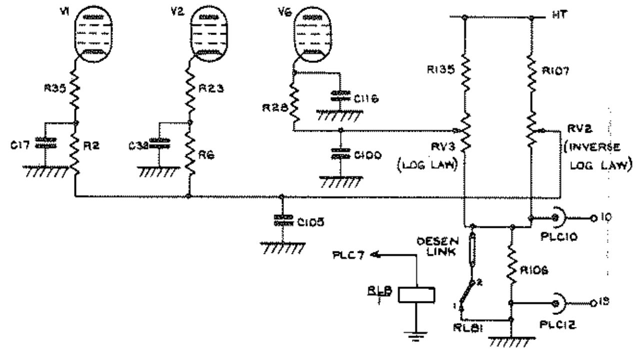


FIG. 12. RF GAIN CONTROL AND CATHODE DESENSITISING SYSTEM.
(USING KEYED 24V D.C. SUPPLY.)

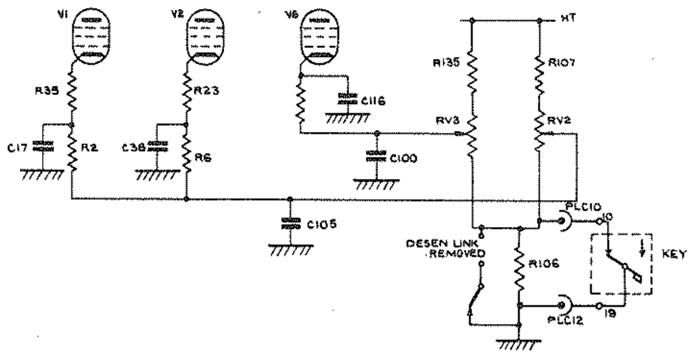
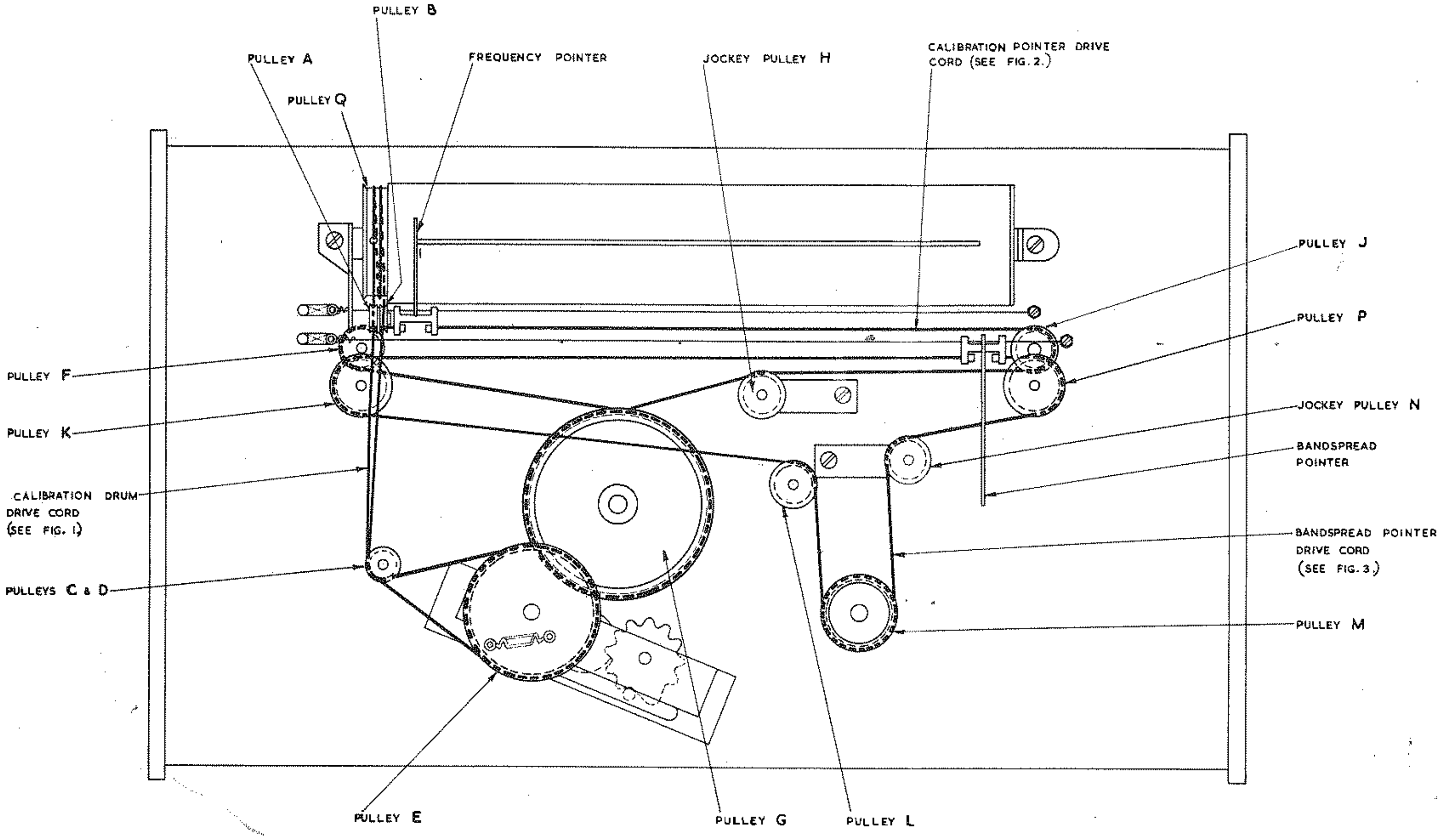


FIG. 13. RF GAIN CONTROL AND CATHODE DESENSITISING SYSTEM.
(USING KEY BACK CONTACTS.)



FRONT VIEW OF INNER FRONT PANEL

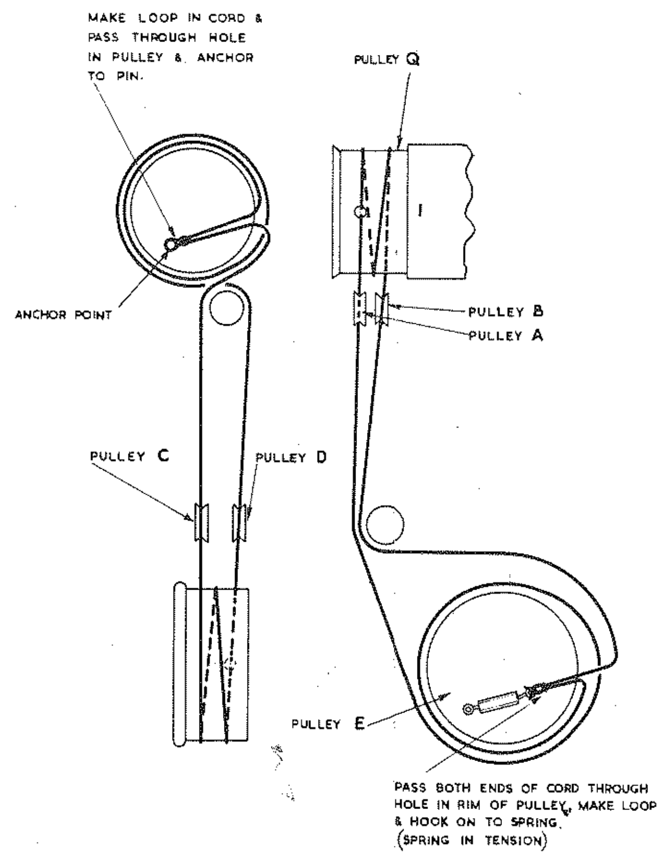


FIG. 1.

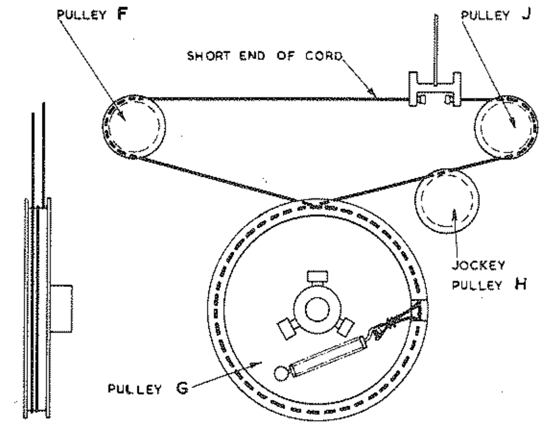


FIG. 2.

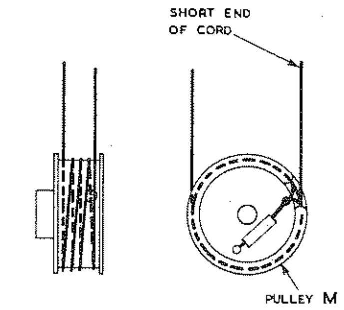


FIG 3

Issue No. 1
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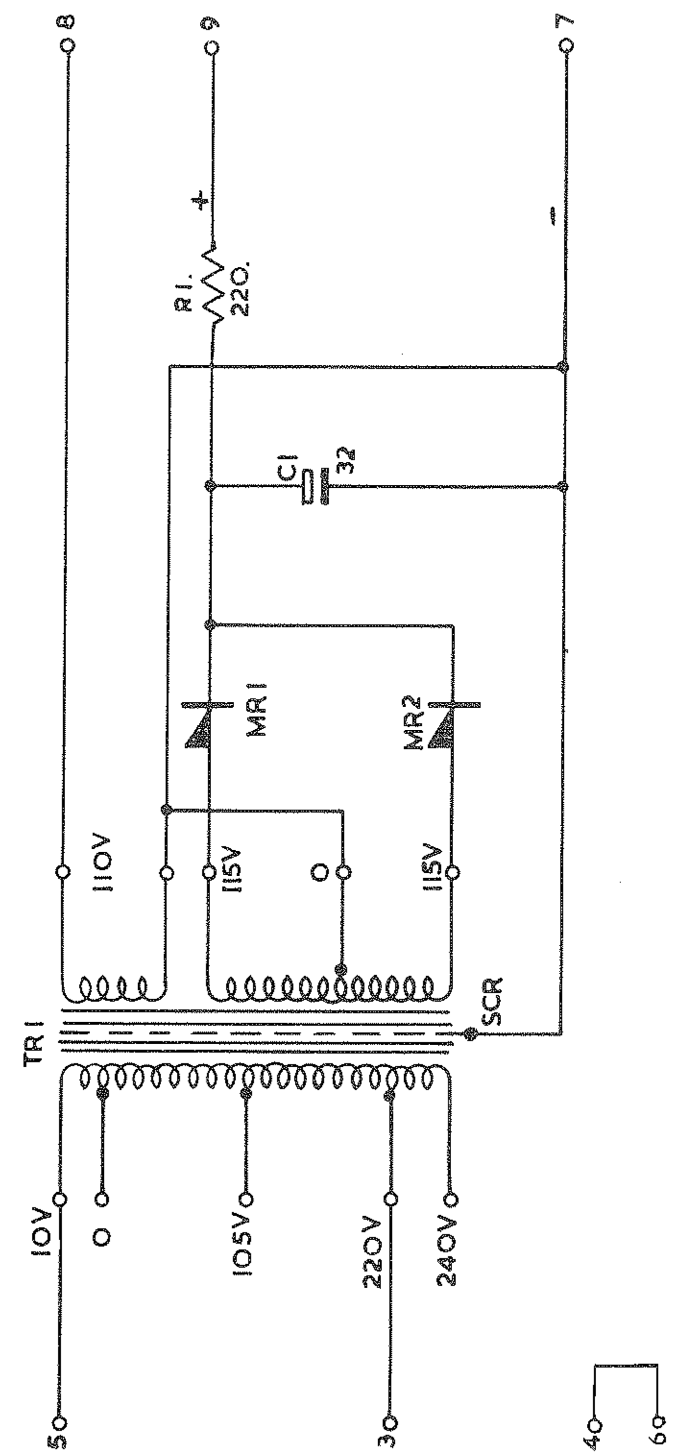
WZ.14128 D

DRIVE CORD REPLACEMENT DIAGRAMS "ATALANTA" RECEIVER TYPE 2207C



Issue No. 3
Sheet No. 1

CIRCUIT DIAGRAM SUPPLY UNIT TYPE 2202A

WZ.14312/B

Full Wave Voltage Doubler Power Supply for Marconi Atalanta