By Ian Batty

Your radio is tuned and ready
Panasonic's Radar Matic R-1000

Transistors and clockwork combine to provide convenience and elegance in this 1965 Japanese radio.

In the early days of electricity, houses were only wired up for electric lighting, so when other electricity-powered accessories became available, initially you had to run them off the light sockets. I was fascinated to learn that multinational giant Panasonic was founded by an impoverished Japanese businessman whose first product was a light socket double-adaptor.

The early days of Panasonic

Konosuke Matsushita, born in 1894, came from an affluent turned impoverished family and had an apprenticeship cut short due to the business collapsing. He found another apprenticeship at a bicycle shop before landing a job with the Osaka Electric Light Company. He was eventually promoted to a position as an electrical inspector.

When his invention, a new and improved light socket, left his boss unimpressed, 22-year-old Matsushita decided to set up his own business. But he struggled to balance manufacturing and marketing, with his sockets not being popular enough. The company nearly went bankrupt until an unexpected order of 1000 insulator plates for fans came in.

As the company was rapidly expanding, Matsushita saw the potential for an efficient bicycle lamp, but wholesalers were skeptical about the stated 40 hour lifespan. Matsushita decided to send the lamp directly to bicycle store owners. This led to a marked increase in orders.

Matsushita focussed on mass production of electrical consumer goods, lowering the sales price and thus in-

creasing the percentage of people who could afford it. This finally put Matsushita and the National brand on the map. Now the company is called Panasonic; it is one of Japan's largest consumer electronics company today.

The Panasonic R-1000

The 50s and 60s saw intense competition in postwar Japan. Sony's Masaru Ibuka, co-founder with Akio Morita, was famous for grumbling when his company's technological leadership resulted in it being dubbed a "guinea pig".

It's easy to think of Matsushita's National brand as following in Sony's wake. The set described here, though, is not merely a follower. It has one particularly innovative feature: autotuning.

This is quite different from the "auto-tune" software used by hip-hop artists like Kanye West and T-Pain, or pop singer Cher!

I was offered this set by a fellow HRSA member to review; he'd collected several of these fine examples of 60s ingenuity, and it was a pleasure to examine their workings.

Panasonic innovation

There's no easy comparison for this set. The Toshiba 15M-915, from around 1968, has 15(!) transistors but a very similar overall design. Sony appears to have waited until they offered AM/FM portables before including automatic tuning.

These examples aside, some automatic/preset tuned valve radios were offered as early as the late 1930s. So it looks like Panasonic were the first to market with auto-tuning transistor radios. They followed up in the early 70s with their RF-6070 AM/FM set, also using a spring motor mechanism.

Spring-powered auto-tuner

The radio comes in a "leather" finish black case with bright inset metalwork, including the speaker grille, tuning dial and metal frame.

The flip-out handle at the back is a winder for the clockwork motor. Since this auto-tuning radio predated the availability of variable-capacitance diodes (varicaps) with capacitance ratios approaching 10:1, an all-electronic system was not possible for the broadcast band at the time.

So the folks at Panasonic used a proven method: a spring motor. These were used from the earliest phonographs until the 40s. Being mechanical, there's no battery-draining electric motor, so the R-1000 is as economical on batteries as comparable manually-tuned sets.

Circuit description

The receiver section uses a configuration that had become more-or-less standard by the year this set was released, 1965. Using ten germanium PNP transistors and three diodes, it's a seven-transistor superhet with a three-transistor control circuit.

Converter TR1, a 2SA102, is a drift type, superior to the alloyed-junction OC44. This circuit uses collector-base feedback. Many such circuits will stop working if you try to inject a signal into the converter base.

Unusually, this converter does use a padder, 170pF capacitor C5. I'll elaborate on this later. The 455kHz IF signal from the converter is fed to the first IF amplifier, based around transistor TR2, via first IF transformer T1. It's the conventional arrangement, with tuned, tapped primary and untuned, untapped secondary.

TR2, a 2SA101, operates in a standard gain-controlled circuit. Base bias current through 68kΩ resistor R4 is under 100μA, allowing the rectified DC from the demodulator to take effective control of the first IF stage gain as received signal strength rises.

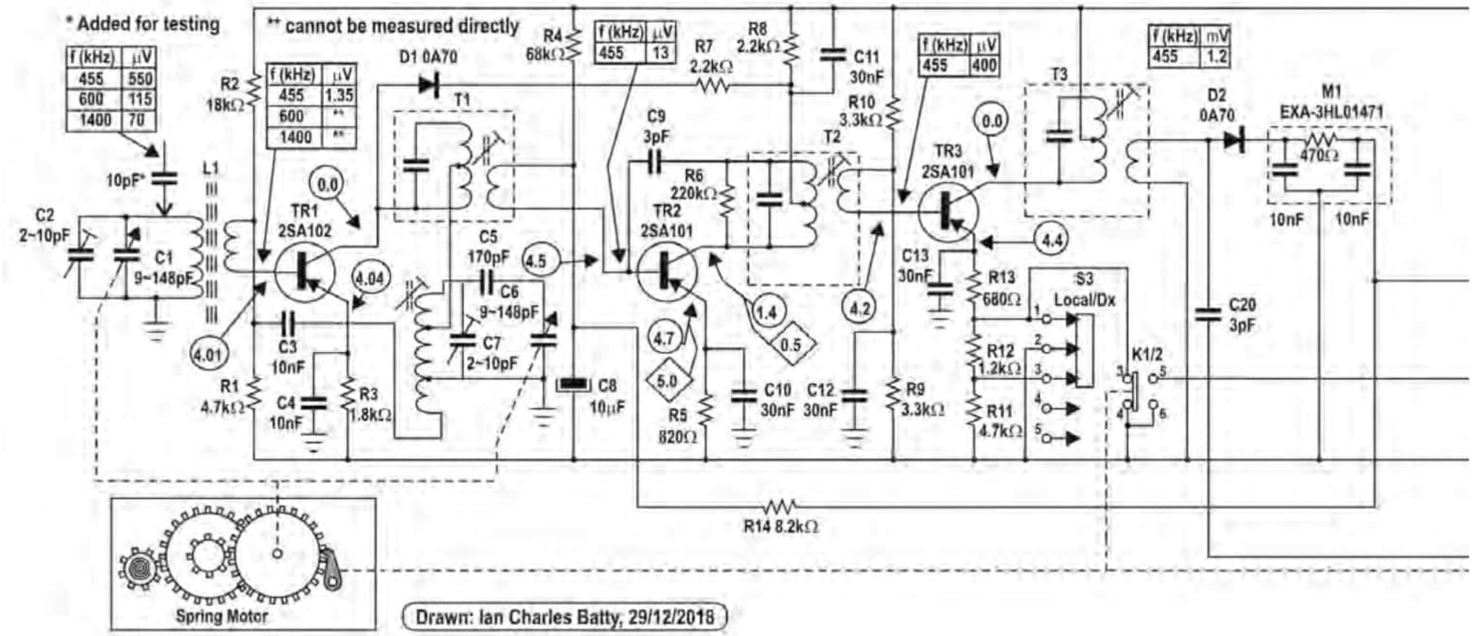
TR2's base is bypassed to ground via 10μF capacitor C8. It's an electrolytic, pretty much a no-no at radio frequencies (even 455kHz) as any deterioration in C8 is likely to cause IF instability. If you get an R-1000 with an IF circuit which oscillates or shows other bad behaviour, be sure to replace C8.

The first IF stage has collector-base neutralisation, confirming that the 2SA101 operates similarly to an OC45.

Second IF transformer T2 also has a tapped, tuned primary with an untuned, untapped secondary. T2's primary is shunted by 220kΩ resistor R6. It's there to broaden out T2's response and increase the IF bandwidth. TR2's collector load comprises T2 at intermediate frequencies and 2.2kΩ resistor R8 at DC, bypassed for IF by 30nF capacitor C11.

With no signal, the junction of T2 and R8 sits about 1.3V above ground, so OA70 diode D1 is normally not in conduction.

The left (above) and right (below) sides of the Radar Matic R-1000 shown at close to actual size. The case is plastic with a leather-like finish, while the grille and sides are metal.



When the auto-tuning switch (S2) is pressed, it energises relay K1 which shorts out the audio stage. This then moves a lever connected to the relay, which applies pressure to a spring. This action unlocks an impeller to move a series of gears to rotate the spring motor. The impeller comprises four blades, plus two that control the spring motor's rotational speed via air resistance. The spring motor adjusts the tuning capacitor (C1/C6) until a signal is detected. This signal is then converted to an IF signal by the 2SA102 (TR1) before being filtered and amplified by TR2 and TR3. This signal is detected in the trigger stage (TR8 & D3) before being amplified by TR9 and then causing relay K1 to open. This then returns the lever to its original position, locking the impeller and thus stopping the adjustment of the tuning capacitor.

As signal strength rises and the AGC circuit comes into action, TR2's bias is reduced, and its collector current falls. This causes the voltage across R8 to fall, and very strong signals will reduce R8's voltage drop to the point that D1 begins to conduct. This conduction will shunt some of the IF signal at converter TR1's collector to ground, thus extending the range of the AGC circuit.

TR3 feeds third IF transformer T3, with a tuned, tapped primary and untuned, untapped secondary. T3's secondary feeds demodulator diode D2, also an OA70, and capacitive voltage divider C20/C21. At only 3pF, C20 has little effect on the demodulator, and we'll look at that signal pickoff soon.

Demodulator D2's output feeds M1, an integrated resistor-capacitor filter. M1's audio output goes to 10kΩ volume control pot R15. There's also a connection, via 8.2kΩ resistor R14, back to TR2's base (the first IF amplifier). 10µF capacitor C8 filters the audio signal, delivering the smoothed AGC signal to TR2.

The audio output section uses TR4 (2SB173) and TR5 (2SB171) in a direct-coupled circuit. The DC operating conditions are established by the voltage divider formed by resistors R16 & R17, holding TR4's base at a constant voltage, and stability is maintained by local negative feedback due to emitter resistor R18.

Unusually, this stage also has collector bias applied to the base of TR4 via 10kΩ resistor R17. These two DC feedback paths allow the designers to assume a constant base bias for TR5, which gains DC stability from emitter feedback via 1kΩ resistor R20. Direct coupling eliminates some capacitors, giving a reduced component count and potentially improving low-frequency response.

TR5's collector feeds the primary of phase-splitting transformer T4, and its tapped secondary provides the antiphase signals to drive the Class-B output stage comprising transistors TR6 & TR7, both 2SB176s.

The output stage gets around 150mV of forward bias, stabilised for temperature, from MT-250 thermistor "Th". Local collector-base feedback is applied by 6.8nF capacitors C18/C19.

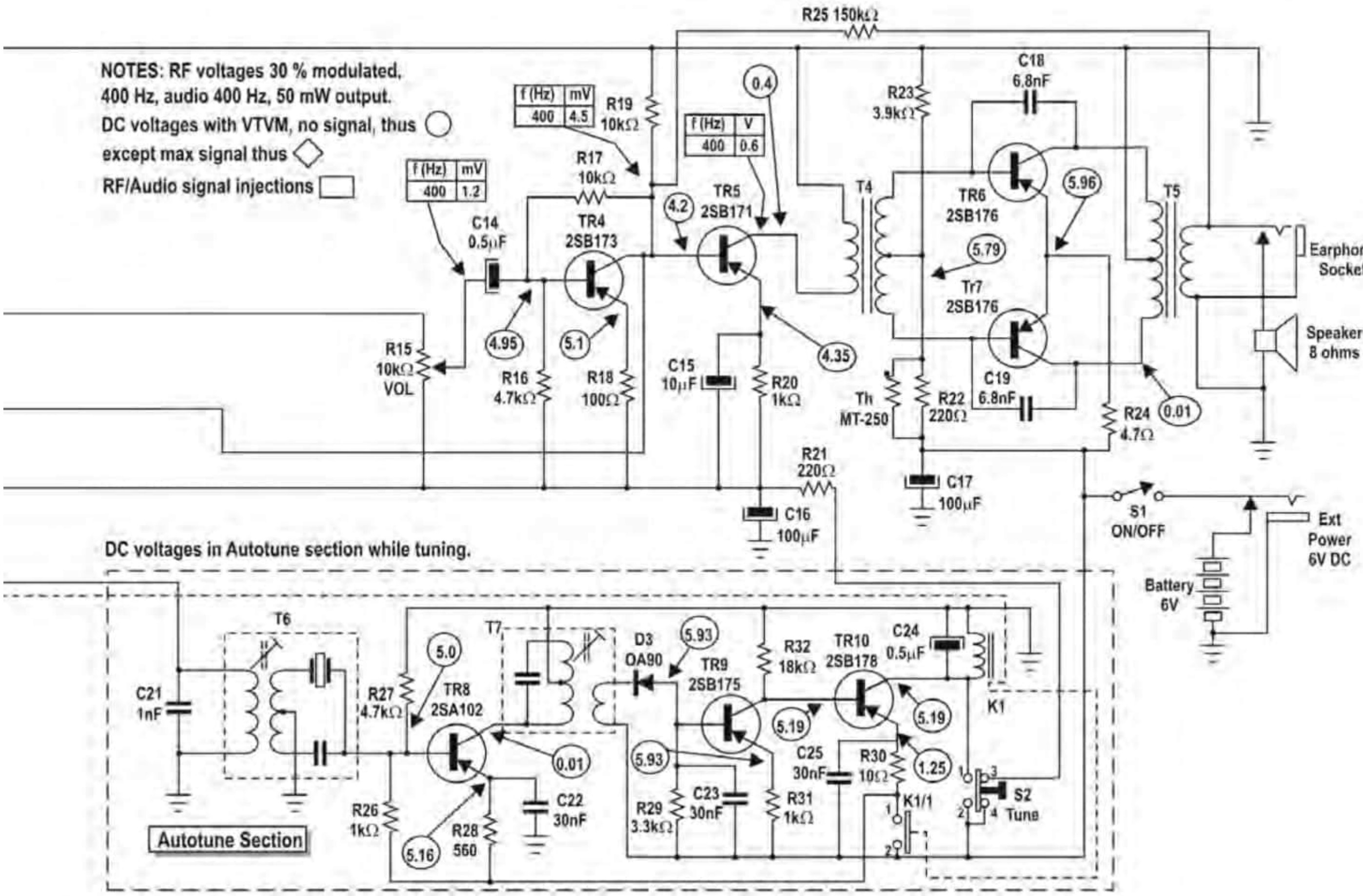
Output transformer T5 matches the collectors of TR6/TR7 to the 8Ω speaker, which is connected via the headphone socket. There's also overall audio feedback from the speaker/earphone to TR5's base via 150kΩ resistor R25.

Auto-tune circuit

The auto-tuning circuit begins with capacitive divider C20/C21. The signal developed across C21 is applied to the primary of transformer T6. T6's secondary is connected to an internal ceramic filter.

Similar to a quartz crystal, this is a piezoelectric device with a very narrow frequency response; in other words, it has a very high Q. Ceramic filters are cheaper than quartz crystals, and substitute well if very high precision is not needed.

This filter's -3dB bandwidth is exceptionally narrow, so it will only pass a signal when the frequency is very close to 455kHz. The filter's output feeds a conventional IF amplifier stage, based around transistor TR8, which in turn feeds conventional IF transformer T7. T7's output goes to OA90 diode D3, and its rectified DC output drives the direct-coupled combination of TR9/TR10.



Since TR9 only gets bias when D3 is rectifying a 455kHz signal, TR9 is usually cut off and TR10 gets forward base bias via 18kΩ resistor R32.

R32's biasing would normally put TR10 into full conduction and would pull auto-tuning relay K1 into closure. But even with TR9 inactive, TR10 is usually off.

In normal operation, relay contacts K/1-2 are open, so TR10's emitter circuit is open; no collector current flows and relay K1 does not close. The autotune circuit is dormant until the user presses the AUTO TUNING bar and closes S2. This supplies battery current to K1 and cuts off DC supply to the audio preamp and RF/IF stages as S2/3-4 is open.

K1 closes immediately, so before the user can release S2, emitter current is supplied to TR10 (and power to amplifier TR8) so that TR10 holds K1 in.

Search contact K1/3-4 will also be open, allowing "Local/DX" switch S3 to take control of second IF amplifier TR3's gain, while search contact K1/5-6 shorts TR5's base to ground, muting the audio, and K1's armature releases a brake on the spring motor, allowing it to drive the tuning capacitor.

As the spring motor rotates, the signal frequency from the converter sweeps across the IF amplifier's bandpass. As the signal's frequency reaches the sharp bandpass peak of the ceramic filter, it will pass a signal through amplifier TR8 to D3. D3's rectified DC output will bias TR9 strongly on.

When TR9 switches on, it shorts out the forward bias on TR10, so TR10 cuts off and K1 releases, resulting in the spring motor's brake being applied. Search contact K1/5-6 opens, unmuting the audio, K1/1-2 opens, turning off TR8 and TR10 and K1/3-4 closes, returning TR3 to maximum gain.

During auto-tuning, the K1/3-4 contacts open and remove the short across Local/DX switch S3. This connects R12 (1.2kΩ, DX) or adds R11 (4.7kΩ, LOCAL) in series with R13, progressively reducing TR3's emitter current, and thus its gain.

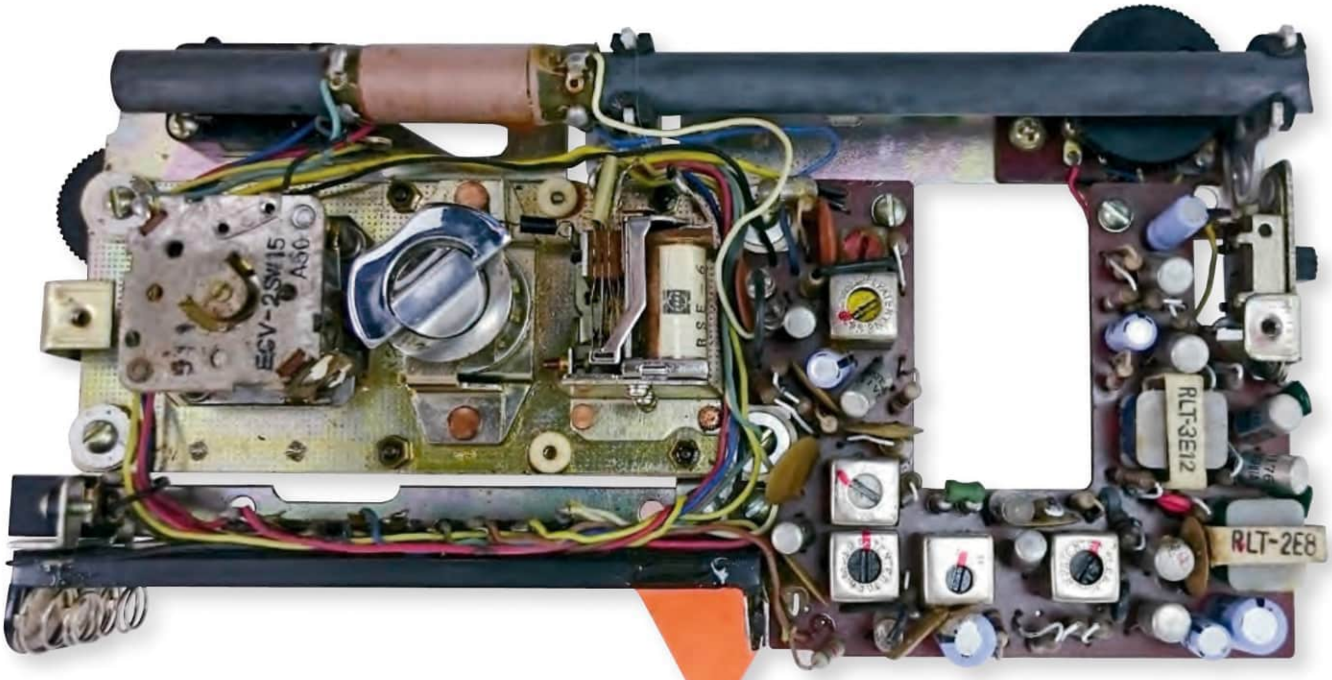
This is used to determine how strong the received signal at a particular frequency needs to be for the auto-tuning sweep to stop, to reject weak stations if necessary. If auto-tuning cannot detect a station, pressing in the manual tuning thumbwheel allows conventional tuning.

Tuning capacitor C1/C6 uses semi-circular "straight line capacitance" plates that allow full 360° rotation, hence the use of padder C5. It's a similar construction to that used in the DKE38 Kleinempfanger described in the July 2017 issue (**siliconchip.com.au/Article/10728**). However, the R-1000 uses air spacing while the DKE38 (from the 1930s) used a plastic dielectric.

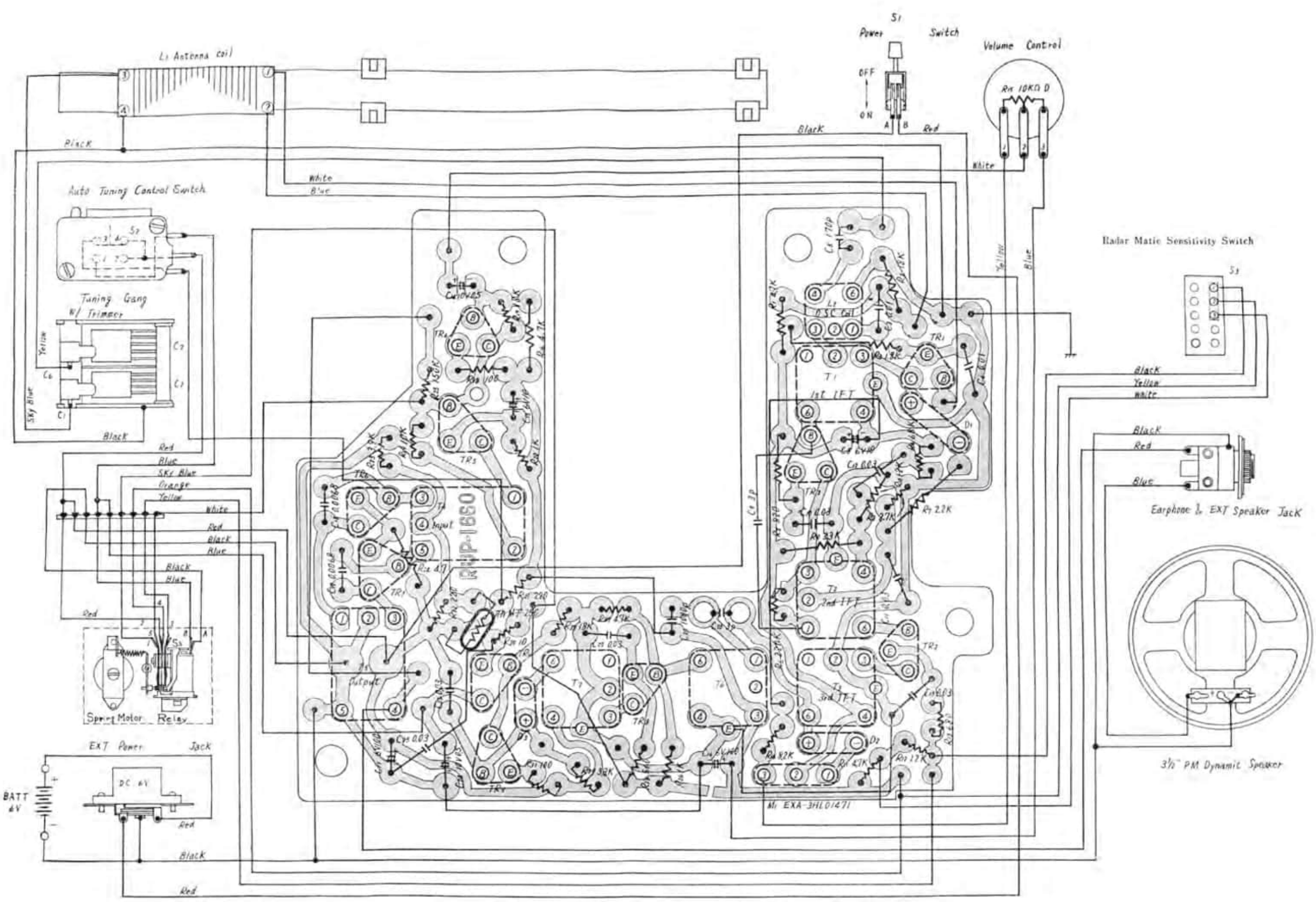
Motor speed regulation

I remember, as a small child, taking an old alarm clock to bits. Imagine my surprise when, having dismantled the escapement (the part that goes "tick, tock"), the hands spun like a fan! A balance wheel regulator would be over-engineering for the Radar Matic's spring motor, but it does need some kind of speed control.

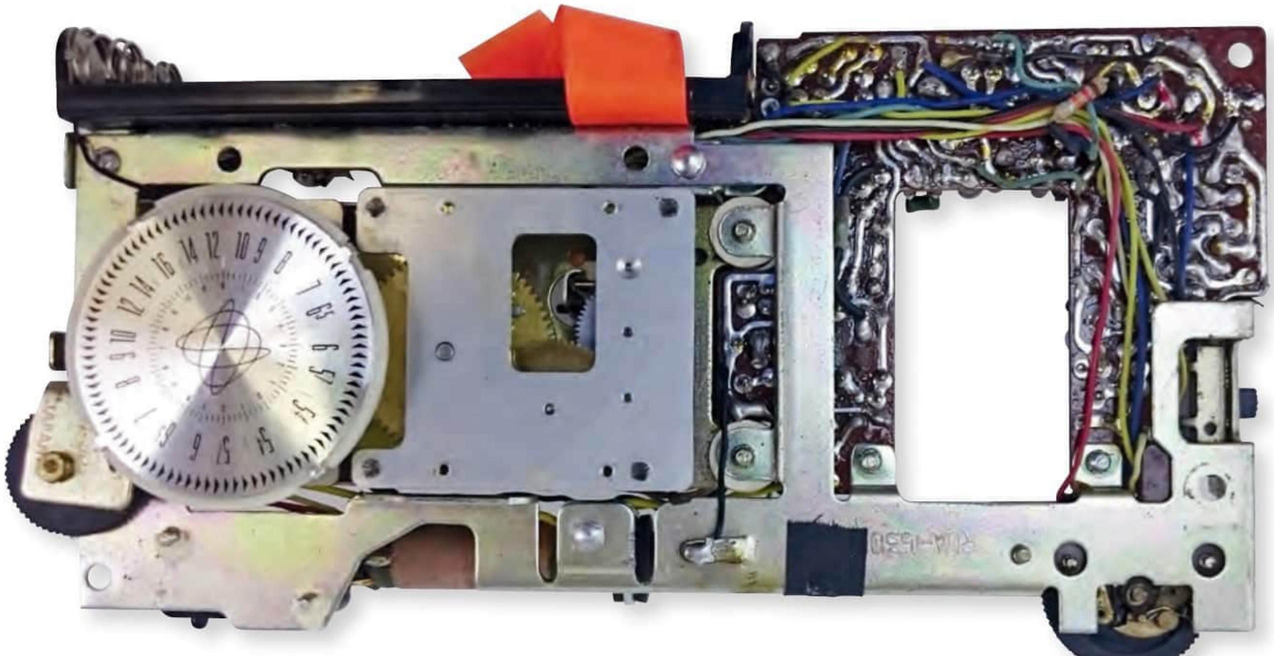
The solution is to use a step-up gear train connected to the motor at the "input" end, and a four-bladed paddle wheel at the "output". As the paddle spins, air friction balances the driving force to give a reasonably constant drive train speed. It dissipates energy, so it's a bit like an electronic shunt regulator.



The auto-tuning switch (S2) is at the top-left of the chassis just under the ferrite rod. The main PCB is at the right, while the smaller copper-plated sheet at left holds the tuning gang, spring motor and auto-tuning relay K1.



The PCB wiring diagram is reproduced from the service manual which can be found at Kevin Chant's website (www.kevinchant.com/uploads/7/1/0/8/7108231/r-1000.pdf). Power switch S1 and Auto-tuning control switch S2 are shown in the off position, while Local/DX switch S3 is in the DX position.



The underside of the chassis sits at the front of the case as seen by the location of the tuning dial. The sensitivity switch (Local/DX S3) is also visible at the far-right, centre end of the chassis. An orange strip of tape hangs off the chassis and is used to hold the batteries in place.

Cleaning up this set

The review set was in good cosmetic condition, so a light clean had it looking just fine.

The auto-tune feature was a bit fussy, working best with the set upside-down. Clockwork mechanisms don't tolerate dust, grime or gummy lubricants well, so I cleaned the mechanism with an evaporating contact cleaner. Be aware that popular "rust easers", based on fish oil, are not ideal for lubricating fine mechanisms. After that, it worked a lot more consistently.

How good is it?

Like the Sony TR-712, it's madly sensitive: 55µV/m at 600kHz and 27µV/m at 1400kHz for 50mW output. Unsurprisingly, these readings are for signal+noise to noise (S+N/N) figures of 6dB and 7dB respectively.

For the more standard 20dB S+N/N it's 150µV/m at 600kHz and 110µV/m at 1400kHz. In testament to this set, it can just pick up 774 ABC Melbourne inside my screened room – no easy feat.

The converter's 455kHz sensitivity of 1.35µV for 50mW output backs up the air interface figures. As this converter uses base injection, it wasn't possible to test at the base with 600kHz and 1400kHz signals.

I had to use my standard method of coupling to the tuned primary via a 10pF capacitor. This has the advantage of minimal detuning of the circuit and giving a repeatable indication for testing.

IF bandwidth is ±1.8kHz at -3dB and ±34kHz at -60dB. AGC allows some 6dB rise for a signal increase of more than 40dB.

Audio response from antenna to speaker is 130-2200Hz. From volume control to speaker, it's 125~4000Hz. At 50mW, total harmonic distortion (THD) is around 3% with clipping at 200mW for a THD of 10%. At 10mW output, it is 2.5%.

The auto-tuning feature managed to stop at every local station and was able to reliably detect my reference "weak station", ABC 594 at Horsham as well as 7BU in Burnie, Tasmania. On test, it would reliably stop on a 600kHz signal of 150µV/m on DX, and about 1.3mV/m on Local.

Other versions

A later version of this radio was released, the R-1100, then an AM/FM version, the RF-6070. I would love to get my hands on an RF-6070. Later Panasonic offerings in the Radar Matic range with mechanical drives appear to use reversing electric motors.

Japanese part coding

The Japanese Industrial Standard (JIS) semiconductor coding is somewhat more helpful than the chaotic RETMA system. The JIS distinguishes polarities, technologies and applications, but chemistry (germanium/silicon) and power rating are not coded for.

Transistors starting with 2SA are high-frequency PNP BJTs, 2SB are audio-frequency PNP BJTs, 2SC are high-frequency NPN BJTs, 2SD are audio-frequency NPN BJTs, 2SJ are P-channel FETs (both JFETs and Mosfets) and 2SK are N-channel FETs (both JFETs and Mosfets).

Disassembly and reassembly

To dismantle, first carefully remove the winding key by pulling it off – you may need to gently lever it on both sides. Remove the two Philips screws on the back cover. Undo the snaps at the bottom edge and the back will then come off easily.

The chassis is held down by red-anodised screws. For reassembly, be sure to align the Local/DX switch's lever tab with the slide attached to the case, reattach the back and its screws, then push the winding key onto its splined shaft.

Be aware that auto-tune switch S2 connects power to the RF/IF and audio preamp stages and contact corrosion will prevent this. If you have an R-1000 that's "dead", but drawing some 3~5mA, this is probably just the output stage's quiescent current. A quick DC voltage check will show whether S2 is working correctly.

You can find more photos of this set at Radiomuseum: **siliconchip.com.au/link/aapr** SC