Rebecca Mk8

Rebecca was the airborne equipment used during and after WWII to find a small beacon (Eureka), usually dropped earlier to mark a dropping site for parachutists or equipment. Mk8 was the last one of the Rebecca series of airborne receiver/transmitters. The main unit is the TR 8193, made in 1956 by Murphy Radio. This airborne set transmits 140 pulses per second on one of 8 channels between 214-235 MHz, with a peak power of 1kW, and a pulse width of 4 us. The Eureka beacon responds to each pulse on a different frequency, usually 4MHz above the Rebecca frequency, with a 12W pulse of 7us width. These pulses are received by the Rebecca unit on two aerials, one on each side of the cockpit. Their relative strength gives the direction, the delay from transmit to receive gives the range.

The T.R. 8193 Rebecca-8 airborne unit has range and heading measuring capability to Eureka or BABS beacons. Versions are

ARI 5506 (Rebecca - 2)
ARI 5610 (Rebecca - 4)
ARI 5849 (Rebecca - 7)
ARI 23013 (Rebecca - 8)

20 july 2017, Koos Bouwknecht
CONCISE DETAILS
OF
ARI.230I3
REBECCA Mk. 8

Function
Rebecca Mk.8 is a lightweight, miniature, airborne interrogator-responsor, operating over the frequency band 200 - 235 Mc. It is used in high performance single seat aircraft under pan-climatic conditions up to 50,000 feet and provides the following facilities—

1. Interrogates both Eureka Mk.7 and Babs Mk. 4
2. Responds with meter indications of slant range and the condition of being locked to the transponder.
3. Provides heading information when locked to Eureka, and course line information when locked to Babs.
4. Receives code identification signals in headset and lock release for unwanted signals.

Frequency coverage
Eight spot frequencies for both receiver and transmitter between 200 and 235 MHz.

Range
Eureka: 200 miles at 30,000 ft and 60 to 90 miles at 5,000 ft
Babs: 20 miles at 1,000 ft within ± 25 deg from Q.D.M.

Polarization
Vertical

Transmitter
Power Output
1.0 kW maximum

Pulse width
3 µs ± 1 µs

Pulse recurrence rate
140 p.p.s

Receiver
Sensitivity
80 dB down on 0.1V (10µV) for 2:1 s/n ratio

Bandwidth
Not less than ± 1.5 MHz at 6 dB down;
Not greater than ± 5 MHz at 50 dB down;
45 MHz

Intermediate frequency
45 MHz

Left-right sensitivity (adjustable)
Eureka homing. Half scale deflection for 10 degrees off true course
Babs approach. Half scale deflection for one degree off Q.D.M.

Range accuracy
± 2 per cent of maximum range excluding meter

Meter accuracy
± 2 per cent of F.S.D.

System capacity
Eureka Mk.7: 75 aircraft
Babs Mk.4: 30 aircraft

Maximum operational height
50,000 feet

Power consumption
28V at approximately 7A

Main items of installation

<table>
<thead>
<tr>
<th>item</th>
<th>Stores Ref.</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter-receiver</td>
<td>10D/19594</td>
<td>15 in. x 8 in. x 8 in.</td>
</tr>
<tr>
<td>Control unit</td>
<td>10L/16264</td>
<td>7 in. x 5 in. x 4½ in.</td>
</tr>
<tr>
<td>Range and heading</td>
<td>10AF/530</td>
<td>¾ in. dia x 2½ in.</td>
</tr>
<tr>
<td>Boxes junction Type</td>
<td>10D/19595</td>
<td>8 in. x 3½ in. x 6 in.</td>
</tr>
<tr>
<td>Boxes junction Type</td>
<td>10D/20063</td>
<td>8½ in. x 4 in. x 4 in.</td>
</tr>
</tbody>
</table>

(A.L.10, Nov. 56)
Rebecca Mk8

On 5 April 2010, BEagle wrote on the PPRuNe forum:

"The Vampire 11 had a Rebecca 8 set, as did the Jet Provost and Hunter. In 'range only' mode, if you were lucky it had a range of about 40 nm; in 'homing' mode about 20.

The control box was a large, clunky thing with large bakelite rotary knobs. One control selected the letter and the other the number of the associated Eureka 7 channel; for example, Cranwell was C4 and Cottesmore D5 (I think). The morse coding rate for the Eur7 was very student friendly - about 1 word per week! You had to check it as it was quite common for the Rebecca to lock onto a different station to the one you'd selected.

Somehow we flew radio navigation exercises using nothing more than Eur7 and UDF, then flew a DME let down at base using this contraption. At least we had the left/right indicator, rather than the CRT screen the guys who flew Pigs had! You went outbound in the 'DME safety lane', then faffed with L/R and the DI to establish the correct inbound approach course.....uhoh: Fortunately we'd all had several sessions in the Link trainer before trying it for real.

The 'swingometer' range needle used to hunt around the dial unless the Rebecca could sniff out a station; once I was just pulling off the target at Pembrey when the needle went clockwise at precisely the same rate as the g-meter's needle normally moved - except that it kept going...ooh: For a moment I eased off the gas a reflex in case I was overstressing....fortunately I was already climbing. We used to pull out of the dive and immediately check the mirror for the 25 lb bomb smoke - having the distraction of the Rebecca needle moving round the dial out of the corner of your eye was most unwelcome!

The bandwidth of Eureka/Rebecca was colossal - about 4 MHz if I recall correctly. When the JP5A came in with VOR/DME, it seemed like the space age. This was about 1974! But the wonderful Gnat with its offset TACAN was truly magical! We had non-offset TACAN in the GT6 Hunters at Valley, but all bar 2 of the jets at Brawdy had the old Rebecca. The Mk9s had ADF, but no-one taught us how to use it - we just used to listen to music on it. A chum, Dick 'Whizzbang' was a bit of a culture vulture and had a memorable time rocketing with SNEBs at Pembrey whilst listening to 'Ride of the Valkyries' on BBC Radio 3! "
Systems Rebecca Mk7 and Mk8
More version info and submodules

Rebecca Mk7 and Mk8 are identical, except for the BABS function, which is only present in Mk8.

Rebecca version

<table>
<thead>
<tr>
<th>Rebecca version</th>
<th>Mk7</th>
<th>Mk8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beacons supported</td>
<td>Eureka</td>
<td>Eureka, Babs</td>
</tr>
<tr>
<td>Transmitter/Receiver</td>
<td>TR1809</td>
<td>TR8193 (made by Murphy Radio)</td>
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<tr>
<td>Control panel</td>
<td>Type 909</td>
<td>8197 (10L/16264)</td>
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<tr>
<td>Junction Box</td>
<td>X.2004</td>
<td>8196 (10D/19595) or 8355 (10D/20063)</td>
</tr>
<tr>
<td>Range and Heading Indicator</td>
<td>10AF/530</td>
<td>10AF/530 (made by Sangamo-Weston) or 10AF/1561 (made by Murphy Radio M:165)</td>
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<tr>
<td>Antenna switch port/starboard</td>
<td>Type 273</td>
<td>Type 273</td>
</tr>
<tr>
<td>O/R - H coax switch</td>
<td>Type 78A</td>
<td>Type 78A or 514</td>
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Modules Mk8

<table>
<thead>
<tr>
<th>Type</th>
<th>Function</th>
<th>Ref No</th>
<th>Serial no</th>
</tr>
</thead>
<tbody>
<tr>
<td>8202</td>
<td>Chassis</td>
<td>10D/19596</td>
<td>M4028</td>
</tr>
<tr>
<td>8195</td>
<td>Transmitter</td>
<td>10R/13054</td>
<td>M4170</td>
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<tr>
<td>8204</td>
<td>Tuning unit in transmitter</td>
<td>in transmitter</td>
<td></td>
</tr>
<tr>
<td>8349</td>
<td>Receiver RF head</td>
<td>10P/16310</td>
<td>M4146</td>
</tr>
<tr>
<td>8545</td>
<td>IF Amplifier</td>
<td>10U/17210</td>
<td>M5187</td>
</tr>
<tr>
<td>8194</td>
<td>Strobe unit</td>
<td>10Q/16313</td>
<td>M3183</td>
</tr>
<tr>
<td>8320</td>
<td>Dynamotor</td>
<td>10K/18731</td>
<td>M3700</td>
</tr>
<tr>
<td>8193</td>
<td>Dust cover</td>
<td>10D/19594</td>
<td>M3592</td>
</tr>
</tbody>
</table>

Aerials

- Left and right aerials
- Transmit aerial
- Omni receive aerial (babs)

Eureka ground beacon

- RT-44 / PPN1 (In UK known as Eureka, 1943)
- RT-37 / PPN2 (In UK known as Eureka II, 1946)

The junction box is fixed directly to the rear side of the TR8193. It expands the main 28-way plug of the TR8193 into 7 separate plugs, and contains the aerial vibrator, and the A and B power relays.

Revisions

One of the thyratrons in the modulator is replaced by a module with two triodes, forming an oscillator at 140Hz. This signal is used to trigger the remaining thyratron on a more reliable way.

The indicator flag in the earlier versions showed "ON" only when locked i.e. when the AGC level was sufficient. The junction box had a sensitive relay RLC for this purpose. Later versions abandoned RLC and showed "ON" simply when 28V was present on the TR8193.

The first technician courses on Rebecca 8 were in June 1956.
Components of the airborne Rebecca Mk8 system
The junction box plugs directly to the rear of the transmitter-receiver unit.
Circuit details

Main chassis
Front: The front has 2 coax connectors. A pink one for the transmitting aerial on the bottom side of the fuselage of the aircraft. Impedance is 50 ohm I assume. The yellow one is intended to suppress an IFF unit (pos. slope of signal) but can also be used to monitor the range-locking strobe pulse (negative slope of signal).

Rear: The rear side of the TR8193 connects directly to the junction box via a coax input from the Rx antenna switch, and a rectangular 28-pin connector which connections expands to the 27Vdc power supply input, the meter, and control box.

Power supply
The complete unit is powered by 27.5Vdc - 6.2A
The filaments of the 29 valves are series-parallel connected, together 2.65A at 27.5 Vdc. When the mode switch is set from OFF to SB, 27V is applied to the relays and the filaments (7A inrush current). The pilot should wait at least 30 seconds before the mode is set to 200nm, 20nm or babs which starts the dynamotor, mine required at least 10A initial to start running. The transmitter starts then immediately. The 30 sec. delay prevents damage to the CV1759 transmitter tubes.

Once running, the dynamotor takes 1.8A for mechanical losses, fan and field, plus 1.6A for the typical load on the 300V bus. That is:
- 40mA for the strobe unit;
- 25 mA for the RF receiver head
- 5...40mA for the IF strip, depending on signal strength; (fused at 100mA)
- 15 mA (average) for the transmitter
Togethe approx. 85mA

Dynamotor
No load
Input 26.7V / 1.8A
Output +380V, -168V both no load.

Typical load (without transmitter)
Input 24V / 3.4A
Output +280V, -140V typ. load.

The extra load by the transmitter is only 15mA @ 300V dc
The IF strip oscillates (?) at 300Vdc, 280Vdc is a better choice. The DC voltage on the cathode follower output of the IF strip is 10 to 15V dc.
Tuning
Both the receiver and the transmitter have remote controlled tuning motors. Remote tuning is done from the control box by 8 presetted variable resistors.

Each motor is controlled by two relays (forward and reverse) that are controlled by a very sensitive moving coil relay. A current of only + or - 0.4mA is sufficient to activate the forward or reverse drive relay, yet the coil can withstand 8mA in either direction. Such relays were made in 1954 by Elliot (model R350B) or Sangamo Weston ltd (type S.115).

The position of the tuning elements is measured with a potmeter, producing a voltage between 1.7V (approx. 240 MHz) and 22V (approx. 193 MHz). The channel selection in the control panel provides a voltage in the same range. When the difference between these two voltages is more than 0.1V, the motor runs either forward or backwards.

A special circuit eliminates the dead band. With an increase of the reference voltage, the actual tuning position follows as expected. With a decrease there is an undershoot caused by the 33k resistor on the second coil of the moving coil relay. This undershoot is followed by an increase once the 33k offset iswitched-off. This way, the final position is always reached in the same direction and the dead band does not show up.

The transmit frequency at the lower endstop is 193 MHz in my set,
The transmit frequency at the upper endstop is 256 MHz
Tx tuning over this (maximum) range takes 18 sec.

The receive frequency with var.co fully closed is 192 MHz
The receive frequency with var.co fully open is 240 MHz
Rx tuning over this (maximum) range takes 13 sec.

Spec is 200-235 MHz
Transmitter

The transmitter is the only module with a reinforced box, pressurized to 5 psi via a standard tyre valve. This box has a desiccator cartridge with pressure indicator.

Two cold-cathode neon thyratrons (one redundant) CV2349 fire each time the voltage on the 0.5uF storage capacitor has reached 230Vdc. This discharges the capacitor into the HV transformer, providing a 3kV/1A peak pulse to a balanced oscillator (2x CV1759). The RF output is 1kWp, 140 times per second. Waveform see picture.

The average input to the modulator is 300Vdc x 15mA = 4.5W
The average RF output is 1kW x 5us/7ms = 0.7W

The peak voltage on the 47 Ω common cathode resistor is 80V, so the peak current to the transmitter final is 1.6A
There is no intentional jitter of the pulse repetition frequency like in the TACAN system.

Receiver

The receiver is a single superhet with 45 MHz IF, the standard IF frequency since the H2S radar. The min. Rx frequency range is 200 - 235 MHz.
The RF part has a grounded-grid RF amplifier, followed by a triode mixer and oscillator. The oscillator is remotely tuned in the range 154 -190 MHz
The IF amplifier has 100dB gain. Bandwidth is > 2 MHz at -3dB, yet < 5MHz at -50dB
Sensitivity is -86 dBm (5µV) for equal noise and signal.
Typical output pulses are 10Vpk, the max (saturated) output is 20Vpk.

Remote tuning is done from the control box with 8 preset variable resistors. TX and RX are never the same, usually the beacon transmitted 4MHz below its receive frequency like C4

<table>
<thead>
<tr>
<th>TX</th>
<th>RX</th>
<th>Frequency band</th>
<th>Centre</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>208 - 212 Mc/s</td>
<td>210</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>212 - 216</td>
<td>214</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>216 - 220</td>
<td>218</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>220 - 224</td>
<td>222</td>
</tr>
<tr>
<td>E</td>
<td>5</td>
<td>224 - 228</td>
<td>226</td>
</tr>
<tr>
<td>F</td>
<td>6</td>
<td>228 - 232</td>
<td>230</td>
</tr>
<tr>
<td>G</td>
<td>7</td>
<td>232 - 236</td>
<td>234</td>
</tr>
<tr>
<td>H</td>
<td>8</td>
<td>spare ?</td>
<td></td>
</tr>
</tbody>
</table>

The older Rebecca sets could home in on Walter personal rescue beacons at 177 MHz. Clearly, this was no longer possible with Rebecca-8.
**What is received**
Because there may be up to 75 aircraft interrogating the same beacon, a great many pulses may be received at this same frequency. Only one of them is synchronous with the transmitted pulses of this Rebecca unit and should be found in order to measure the distance. The solution is based on a stroboscopic effect: only the response to its own transmitted pulse arrives each cycle at the same delay from the transmitted pulse.

**Strobe unit**
The Rebecca Mk4 from 1955 still had a CRT to show blobs left and right of a vertical timebase line. The Mk7 / Mk8 presents the range and heading to the beacon on a meter. The span of the indicator is 20 or 200 nautical miles, which corresponds to $25 + 20 \times 12.36 = 272 \mu s$ or $25 + 200 \times 12.36 = 2497 \mu s$ (time of flight plus beacon delay). This is about one-third of the time between the transmitted pulses.

To find the reply to its transmitted pulse, a short pulse (walking strobe) is generated in the strobe unit at a variable delay between 10 and 300us resp. 0.1 and 2.5ms after each transmitted pulse. Only received pulses during this gate time are considered. The delay itself is controlled by a slow ramp, gradually increasing the delay until at least 3 successive pulses pass the gate. From then on, the delay no longer ramps but is maintained at the expected time of arrival of the received response pulses. The slow ramp advances with 20nm/s, and the flyback time is 1 sec in both 20nm and 200nm range.

**Strobe gates**
All received pulses are applied to the control grid of 4 pentodes; their suppressor grid is normally held at a negative voltage and the valves are cut-off. Positive "strobe" pulses are applied to this g3 to give a negative anode pulse if the strobe pulse coincides with a received pulse.

The walking strobe generator is followed by two one-shot circuits, to provide four strobe pulses (A,B,C and D) at or just after the expected time of arrival of the response. They are:

A Range gate (V4)

B AGC (V14)

C BABS dash (V17)

D TONE-ID (V7)

All pulses are 30Vpp, and 5us wide except for pulse B which is 8us wide.

Pulse A is the "expected time of arrival". The wider pulse B is used for automatic gain control, and for the heading deviation indicator.

Pulse C is used to detect the longer "dash" pulse in BABS mode.

Pulse D checks if the received pulse is longer than 30us, to produce a 1 kHz tone during a dot or dash of the beacon identifier (ID). Eureka beacons normally respond with short (5us) pulses. However, every few minutes a beacon ID is transmitted as a two-letter morse code by widening the response pulse to 33us during the dots and dashes.

The lower two traces are the 10us and 30us one shots. During the positive slope the current in the anode inductor is cut off, resulting in an overshoot above the +300V HT line. This overshoot is a strobe pulse, coupled to the suppressor grid of a "gate" pentode CV2209.
Range circuit
The control voltage for the walking strobe generator varies between 30 and 200V. This voltage drives the 1mA, 270 deg rangemeter via a 150 kOhm resistor. There are separate zero range adjustments for 20nm, 200nm and BABS mode of operation. BABS beacons have 1 naut.mile = 12.4us internal delay plus the standard eureka delay (25 us?)

The range circuit operates either in **Hold, Search, or Track mode.**

**Hold mode:** Relay D is a memory-type relay which is "set" when the sum of the two heading triode currents is higher than the plate current of the AGC triode.

Without signal, relay contact D is open, and the range meter stays where it was. This occurs when the beacon signal is temporarily interrupted. Hold mode ends after 6 seconds, when the expected signal returns, or when the "strobe" button is pushed to start a new search.

**Search mode:** The contact of relay D is closed, and a negative voltage enters the grid of V10. The anode voltage ramps up slowly to 200V, where polar relay C changes state, so a positive voltage is applied to the grid of V10. The anode voltage of V10 runs down quickly to 20V where relay C changes state again, and the cycle repeats.

**Track mode:** When a response is received at the expected time of arrival (ETA), then a positive impulse enters V10, and the anode voltage drops a little, reducing the ETA to less than the arrival of the next received pulse, so the anode voltage starts to rise slowly, advancing the strobe pulse until pulses are received again in the ETA strobe pulse, and the process repeats.

When the 5us wide strobe pulse exactly coincides with a received pulse, then the anode voltage of V13b peaks at +50V, and its cathode voltage to 15V (see recording). This advances the strobe pulse so the next received pulse arrives outside the strobe pulse.

The triangle trace is the clock from the beacon simulator. The upper trace is recorded at the cathode of V13b

The jitter of the strobe pulse is about 3us, corresponding to 0.3nm. This is not visible on the meter.
Range recordings

The following recordings were made with the available supply voltages minus 123V and +243V dc.
This increased the search cycle to 1.2 resp. 12 sec in stead of 1 s resp 10 s. Further, with a 1mA meter the tracking stops at full scale, but with a 0.5mA meter and 180k extra in series, cycling was OK.

**Search cycle 20nm.**

Timebase is 0.5s/div

Without a beacon, the search voltage rises from 25 to 170V, then relay C changes state and the search voltage drops rapidly until relay C changes state back again. The 0.1uF capacitor was at +85V during flyback and discharges in about 1 sec before the next cycle starts.

With nominal supply voltages, 200V span corresponds to 20nm, and the search speed would be about 20 nm/s

**The 200nm search cycle** takes 14 sec with a 0.5mA range meter connected (and 150k extra series resistor). Without meter the cycle takes only 12 sec (!?)

200V corresponds to 200 nm

De search speed is again 17 nm/s

Time base 2s/div

**Tracking** in 200nm range.

Using a beacon simulator, I tried to change the range as fast as I can without losing lock. It was possible to fly to the beacon at a rather high speed of 6 nm/s. With a higher speed (at the dashed line) tracking was lost and a search cycle takes over until the correct range was found again 12 sec later.

But flying from the beacon was only possible at 1 nm/s without losing lock.

When the range is constant for a while, a higher speed of 2 nm/s was possible.

**Tracking 2**

Some more tests. Tracking was lost at the first vertical line, so a search cycle takes over until the correct range was found again 12 sec later.
**Heading circuit**

The secondary of T5 produces pulses, proportional with the strength of the station where the range circuit was locked to. A typical amplitude is 15V peak. The semiconductor diode prevents ringing. Diode V11b is the (fast) peak-hold function that drives the AGC circuit. Diode V12b is the (slower) peak-hold function that drives the heading circuit. Its hold function is either the upper or the lower 0.1uF capacitor, depending on the actual aerial lobe. The actual lobe is a relay contact, either in the antenna lobe switch, or by Relay E which toggles in synchronism with the babs lobe switching.

The voltage difference \( V_a - V_b \) drives the heading meter via two cathode followers.

The upper trace in this recording is the voltage \( V_x \) in the diagram shown above. You see alternating the voltages \( V_a \) and \( V_b \) here, and during the change-over time of the lobe-switching relay the voltage \( V_g \) which -amplified by V11a - controls the gain of the IF amplifier.

The anode voltage of V11a is on the lower trace.

**Automatic Gain Control**

The AGC is based on the average value of the selected received pulse, not on all other received pulses resulting from interrogation by other aircraft. To prevent the range tracking jitter from entering the AGC circuit, both the reply pulse and the strobe pulse for the AGC gate are made wider. The automatic AGC can be switched-off on the older control panels, in which case a manual gain setting could be set.

**ID tone**

Every few minutes, an Eureka or BABS type beacon transmits its ID as a two-letter morse code by widening the response pulse from 5 to 35us during the dots or dashes. This is detected in the Rebecca strobe unit using the D strobe at 30us after the main strobe pulse. If a pulse is still received there for 5 successive cycles, then a collpitts oscillator produces a 1kHz, 2Vrms signal at the ID-tone output during the dots and dashes. Typical load on the tone output is 100\( \Omega \).

Random pulses can activate the ID oscilator as well, so the ID-tone could be switched-off on the control panel when not strictly needed.
**Aerials**

There is only one transmitting aerial, a half-wave stub in the middle of the bottom of the fuselage. Two homing aerials are at each side of the nose. A fourth, omni-directional receiving aerial is of the same type as the transmitting aerial, placed under the tail section of the fuselage.

The beacon signal is received by two aerials, one on each side of the cockpit. A vibrator type relay (Type 273) switches between these aerials 15 times per second. The relay has RF contacts, that are also used to connect the AGC signal alternating to the left or right terminal of the Heading indicator. If the signal from the left antenna was stronger, then the heading indicator turns to left, and the pilot should make a left turn to fly to the beacon.

**BABS (Blind Approach Beacon System)**

These beacons are placed at the far end of the runway, and retransmit a received pulse on a different frequency just like a Eureka beacon does. However, this beacon has a special antenna that switches the main lobe 15 times per second between just left or just right of the runway. When left, the response pulses are 5us, when right they are 12.5 us wide. The rebecca set uses an omni directional receiving aerial instead of the alternating homing aerials.

The Babs ground antenna is a metal box around a central antenna with two switched slots to alternate the main lobe between left and right of the runway. This box is placed in a corner reflector.

The mobile beacon was placed in a van at the end of the runway.

**BABS circuit in Rebecca Mk 8**

In BABS mode, a third receiving antenna is used, and the feedback contact from the normal antenna switch is replaced by relay E contact which position depends on whether short or long pulses are received. The short/long pulse detection is done in V15-V16-V17. The flipflop V16-V17 is set at each pulse received in the strobe gate. If the pulse is still there 10us later, then the flipflop is reset. Rebecca Mk7 has no babs circuits (V15,V16,V17, RelB,RelE and associated components)
Both the strobe unit and the main chassis of the T.R.8193 have the same rectangular, 28-pole PYE connector, also made by Magnetic Devices Ltd.

<table>
<thead>
<tr>
<th>Pin</th>
<th>On Main Unit</th>
<th>On Strobe Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>gnd</td>
<td>gnd</td>
</tr>
<tr>
<td>2</td>
<td>-150 V</td>
<td>-150 V</td>
</tr>
<tr>
<td>3</td>
<td>Tx pulse</td>
<td>Tx pulse ‘TRIG’</td>
</tr>
<tr>
<td>4</td>
<td>20 nm range</td>
<td>Rx signal ‘SIG’</td>
</tr>
<tr>
<td>5</td>
<td>Strobe release</td>
<td>Strobe release button to -150V</td>
</tr>
<tr>
<td>6</td>
<td>BABS mode</td>
<td>BABS mode (Relay B)</td>
</tr>
<tr>
<td>7</td>
<td>Heading meter +</td>
<td>Heading meter</td>
</tr>
<tr>
<td>8</td>
<td>Heading meter -</td>
<td>Heading meter</td>
</tr>
<tr>
<td>9</td>
<td>Range meter +</td>
<td>Range meter</td>
</tr>
<tr>
<td>10</td>
<td>Aerial switch L</td>
<td>Aerial switch left position</td>
</tr>
<tr>
<td>11</td>
<td>Aerial switch R</td>
<td>Aerial switch right position</td>
</tr>
<tr>
<td>12</td>
<td>Aerial switch return</td>
<td>Aerial switch return</td>
</tr>
<tr>
<td>13</td>
<td>ID tone output</td>
<td>ID tone output (2V, 1kHz into &gt;100Ω)</td>
</tr>
<tr>
<td>14</td>
<td>OFF flag</td>
<td>AGC voltage to OFF flag</td>
</tr>
<tr>
<td>15</td>
<td>Rx signal</td>
<td>20 nm range (Relay A)</td>
</tr>
<tr>
<td>16</td>
<td>+300V to OFF flag</td>
<td>+300 V</td>
</tr>
<tr>
<td>17</td>
<td>AGC link to 18</td>
<td>heaters internal (12.6V)</td>
</tr>
<tr>
<td>18</td>
<td>AGC link to 17</td>
<td>AGC (-1 ... -4V)</td>
</tr>
<tr>
<td>19</td>
<td>Rx tuning</td>
<td>+25V for heaters</td>
</tr>
<tr>
<td>20</td>
<td>Tx tuning</td>
<td>+27 V heaters &amp; relays</td>
</tr>
<tr>
<td>21</td>
<td>Range zero input</td>
<td>Range zero input</td>
</tr>
<tr>
<td>22</td>
<td>Range zero (20nm)</td>
<td>Range zero (20nm)</td>
</tr>
<tr>
<td>23</td>
<td>Range meter return</td>
<td>Range meter return</td>
</tr>
<tr>
<td>24</td>
<td>Range zero (200nm)</td>
<td>Range zero (200nm)</td>
</tr>
<tr>
<td>25</td>
<td>n/c</td>
<td>+85V</td>
</tr>
<tr>
<td>26</td>
<td>Range zero (BAT/BAH)</td>
<td>Range zero (BABS)</td>
</tr>
<tr>
<td>27</td>
<td>+28V dynamotor</td>
<td>heaters internal (19V)</td>
</tr>
<tr>
<td>28</td>
<td>+28V heaters and relays</td>
<td>Front panel -yellow coax plug</td>
</tr>
</tbody>
</table>

The remote control cable can be connected to the stand alone strobe unit with modifications to 9 pins:
- Swap 15 and 4,
- apply -150V to 2, +300V to 16 and +25V to 19 and 20 (common to 1) from external supplies;
- and add two resistors: 18k/3W from 25 to 16 for the +85V supply, and 10Ω/4W from 17 to 27 for stand alone operation of the heaters in the strobe unit.
Valve list

function, equivalents filament current

Receiver, RF
V1 CV417 grounded grid triode, EC91 0.3A
V2 CV858 6J6 mixer/local osc. 0.45A total 0.45A @ 12.6 V

Receiver, IF
V1 CV138 IF stage, CV4014 0.3A
V2 CV138 IF stage, CV4014 0.3A
V3 CV138 IF stage, CV4014 0.3A
V4 CV138 IF stage, CV4014 0.3A
V5 CV138 IF stage, CV4014 0.3A
V6 CV137 detector EAC91 0.3A total 0.6 A @ 18.9 V

Transmitter
V1 CV1759 RF triode 1.1A
V2 CV1759 RF triode 1.1A
V3 CV2349 thyratron 0 total 1.1 A @ 12.6 V

Strobe module
V1 CV449 85A2 0
V2 CV140 dual diode 0.3A
V3 CV2209 0.35
V4 CV2209 0.35
V5 CV858 6J6 10us one shot 0.45
V6 CV858 6J6 30us one shot 0.45
V7 CV2209 0.35
V8 CV137 EAC91 0.3
V9 CV140 EAA91 0.3
V10 CV138 EF91, CV4014 0.3
V11 CV137 EAC91, CV4059 0.3
V12 CV137 EAC91 0.3
V13 CV137 EAC91 0.3
V14 CV2209 0.35
V15 CV137 EAC91 0.3
V16 CV137 EAC91 0.3
V17 CV2209 0.35 total see ckt diagram

In total 29 tubes (valves)

Later versions have:
CV137 replaced by CV4059 (EAC91)
CV138 replaced by CV4014 (EF91)
CV140 replaced by CV4025 (EAA91)
CV2209 can be replaced by 6F33 or CV4064
Control unit Type 8197 for the Rebecca Mk8

The control panel has 6 switches:
SW1 selects the operate mode:
  OFF-Standby- 200nm - 20 nm - Beam Approach Tune-Beam Approach Home.
SW2 selects one of eight receive frequencies
SW3 selects one of eight transmit frequencies
SW4 selects the omnirange (O/H) or home (H) aerials
SW5 switches the morse code from the beacon to the pilot's headset
SW6 Pushbutton to release a strobe cycle
The Rebecca Mk7 and Mk8 systems have a combined Range and Heading meter. Inside are classical moving coil instruments, a few resistors, and a magnetic actuator for the ON flag. Both movements are fully balanced, and have high damping.

The original 10AF/530 has an 1mA range meter, a +/- 100uA heading meter, and an "ON" flag which can cover the static "OFF" text below it.

The improved type 10AF/1561 is identical, except that the flag has a third position, indicating "X10"

Both indicator types have a single, 6-way connector.

A red pin marks the positive side.

A-B  heading indicator 419 Ω  +150 / -100 uA fsd
C-D  range meter 354 Ω  1mA fsd
E-F  "ON" flag 548 Ω  12mA "ON"

The Heading moving coil is shunted with resistor to get 100uA in either direction. The Range meter has a magnetic calibration to indicate exactly 20 at 1mA. The ON flag needs at least 12mA (7V) to show "ON". This flag only indicates that the Rebecca set is turned on, not that the system is locked to a beacon. Maybe there was an external, very sensitive relay on the AGC output to drive the ON flag - only when a beacon is responding.

This indicator was made by
Sangamo Weston Ltd, Enfield Middx, England
Murphy Radio Ltd  Type M:165 APP. No W.R.517
Weight 1.25 Lb MTG. - ANTI VIB.
Aerial switching

The vibrator Type 273 was used in all Rebecca systems from Mk4 to Mk8 to switch the port or starboard aerial to the receiver input. It functions like a vibrator, with speed stabilized by an oscillating disc at 22 - 23 c/s. With a typical pulse repetition frequency (prf) of 170 c/s, each cycle has 4 pulses from the port aerial, and 4 from the starboard aerial.

There is only a single switch-over contact to switch both the aerials and the feed back to the heading circuit in the strobe unit to get a perfect synchronization.

In BAT or BAH modes, the vibrator is locked in the "port" position by earthing pin 5.

**Technical data:** The coil resistance is 450 Ω, so the continuous current is 60mA at 27V. (1.6W) When oscillating, the average coil current is 25mA, (40mA pk). Impedance of the shielded RF contacts is 50 ohms, impedance mismatch varies from 1.2:1 to 1.4 to 1 in the frequency range 174 - 236 Mc. Cross-talk is less than 5%

The omnirange - home switch is the Type 78A, shown here. It is a coax relay.

Later versions had the type 514 coax relay.
Adjustments

All adjustments are on the strobe unit.

RV1 thru RV5 calibrate the range meter.
RV8 thru RV10 calibrate the heading meter.

<table>
<thead>
<tr>
<th>adj</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV1</td>
</tr>
<tr>
<td>RV2</td>
</tr>
<tr>
<td>RV3</td>
</tr>
<tr>
<td>RV4</td>
</tr>
<tr>
<td>RV5</td>
</tr>
<tr>
<td>RV6</td>
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<tr>
<td>RV7</td>
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<tr>
<td>RV8</td>
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<tr>
<td>RV9</td>
</tr>
<tr>
<td>RV10</td>
</tr>
<tr>
<td>RV11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>adj</th>
<th>Function</th>
<th>Setting</th>
<th>Potmeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV1</td>
<td>full range 20nm and ba</td>
<td></td>
<td>5k</td>
</tr>
<tr>
<td>RV2</td>
<td>full range 200nm</td>
<td></td>
<td>5k</td>
</tr>
<tr>
<td>RV3</td>
<td>zero range ba</td>
<td></td>
<td>100k</td>
</tr>
<tr>
<td>RV4</td>
<td>zero range 200nm</td>
<td></td>
<td>100k</td>
</tr>
<tr>
<td>RV5</td>
<td>zero range 20nm</td>
<td></td>
<td>100k</td>
</tr>
<tr>
<td>RV6</td>
<td>AGC level</td>
<td></td>
<td>20k</td>
</tr>
<tr>
<td>RV7</td>
<td>10us delay (BA dash)</td>
<td></td>
<td>220k</td>
</tr>
<tr>
<td>RV8</td>
<td>Zero heading</td>
<td></td>
<td>10k</td>
</tr>
<tr>
<td>RV9</td>
<td>full scale heading (non BA)</td>
<td>30k</td>
<td>50k</td>
</tr>
<tr>
<td>RV10</td>
<td>full scale heading (BA)</td>
<td></td>
<td>30k</td>
</tr>
<tr>
<td>RV11</td>
<td>30us delay (Tone code)</td>
<td></td>
<td>330k</td>
</tr>
</tbody>
</table>
Special components in the TR 8193 set.

A : Relays

The Rebecca Mk7/8, from 1956 had some extremely sensitive relays, with a sub-mW coil sensitivity. These relays are sensitive for vibration and shock and it is impressive that they were used in aircraft at that time.

A1. Moving coil relay (2-off)
Each tuning motor is controlled via a forward and a reverse relay, which are controlled by a moving coil relay. The moving coil is like a mA meter, placed around a permanent magnet. A small vane is attached which is the moving contact. To handle the low contact pressure, both the vane and the contacts are made of 80% platinum, 20% iridium.

The coil has two separate windings of 350 Ω each. If the current in both coils in series in either direction is:
- < 0.12 mA Both contacts are guaranteed open
- > 0.4 mA One contact is closed;
- < 8 mA does not damage the coil
Sensitivity is 0.4 mA x 0.28 V = 0.1 mW!!

UK Manufacturers in 1954:
- Elliott (model R350B)
- Sangamo Weston Ltd (type S.115)
- Electro Methods Ltd, Stevenage (type 416)

A defect moving coil relay can be replaced with a 4-transistor circuit although the dead band is larger.

A2. Telephone relay (3-off)
This polarized relay was patented by R.E.H. Carpenter in 1947 (US2559399). Telephone mfg co, UK
The relay has two coils, each 1500 Ω. When the current in both coils in series in either direction is:
- < 0.12 mA then the previous contact position is maintained
- > 0.12 mA then one contact is closed, depending on polarity.
Three of these polar relays are used in the RT 8193 (Rel C, D and E in the strobe unit).

The sensitivity of this relay is remarkable: 0.12 mA x 0.4 V with both coils in series is 0.05 mW!!

This is a record I think.

Problem: the magnets attract iron particles which shorted the moving contact to the case in one of the relays.
**B : Murphy transformers**
The TR 8193 has 5 small reactors, and 6 transformers. All are wound on a tiny E-I ferrite core, and potted in a round mould. The transformers **T1, T3 and T5** have a long primary on 300V, and a short secondary, biased on -44V. All are wound with very thin wire without additional insulation.

After 50 years, either the primary or the secondary was interrupted, but not fully - the resistance went from a few hundred ohms to several kOhm.

It is nearly impossible to re-wind the original transformer because the ferrite core is brittle, and glued inside the bobbin.

So I decided to remake the transformer on a EE core with 900 primary turns and 200 secondary turns. This worked perfectly. The new transformer fitted quite well in the available space.

The ringing of the 100mH primary with the internal and external capacitances was 80kHz, not far from the original 100 kHz.

**C : TCC Visconol-X capacitors**
These metallized paper capacitors, impregnated in PCB oil, are used in the strobe unit as timing capacitors. After 50 years, they are very leaky, with shunt resistances of a few MOhm. Nearly all had to be replaced by modern foil capacitors.