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The Eddystone EA12

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Dr Bruce Taylor HB9ANY describes Eddystone's ultimate top-line amateur band receiver.

Stratton & Co of Birmingham had accumulated over 37 years of experience manufacturing shortwave radio receivers when they launched the Eddystone EA12 model in 1964, **Fig. 1**. At this time miniature thermionic valves had reached their apogee of performance and reliability, and their RF characteristics hadn't yet been surpassed by the embryonic semiconductor technology that would eventually mature to dominate the world of radio electronics. In fact, the 12-transistor Eddystone S960 communications receiver was discontinued in 1964 because it worked less well than the valve 1962 S940 model that it was supposed to replace!

The better classic Eddystone receivers from this period are now collectors' items that can be quite readily restored to original specifications. Although they have fewer bells and whistles than modern radios, they are very well engineered, have excellent performance, and are straightforward to maintain and a pleasure to operate.

Heritage

The origin of the EA12 can be traced back to the very successful Eddystone S750 model (see *Practical Wireless*, August 2020), a general-coverage communications receiver of which more than 2000 were made between 1950 and 1958. The receiver was Eddystone's first true double-conversion set, with a tuneable converter to the first IF of 1620kHz followed by a frequency changer to a second IF of 85kHz. The S750 used all-glass miniature valves, had continuously variable selectivity and separate RF, IF and AF gains, and introduced the wide open 'slide-rule' tuning dial that would be the striking visible hallmark of many future Eddystone receivers, including the EA12.

Since the early days of the company many Eddystone staff, such as **EJ 'Pick' Pickard G6VA**, **George Brown G5BJ** and Chief Engineer **Bill Cooke GW0ION**, were licensed radio amateurs and the works had its own station with callsign G6SL. Project Engineer **Jerry Walker G5JU** published review articles in amateur radio magazines, as well as many construction articles using Eddystone components. Hence it was no surprise that the factory developed a modified version of the S750 specially for the amateur bands and this was introduced in 1956 as the Model 888. It was superseded the following year by the 888A with a product detector for improved SSB reception and a total of 550 of both versions were made.

After production of the 888A ceased in 1961, Eddystone's Commercial Director **Arthur Edwards G6XJ**, who was himself a keen CW/DX HF band operator, pressed for the manufacture of a more modern high performance amateur band receiver, but Technical Director **Harold Cox** thought that the market for such a set was too small to justify the cost of the development that would be required. Then fortuitously an opportunity arose that allowed the dream to become reality.

Conception

In 1962 Eddystone introduced a high performance 15-valve general coverage communications receiver called Model 830 that was designed to the specifications of a Swedish customer. It was the first of a very successful series of receivers that ran to 12 versions and remained in production until 1973. The 830

Fig. 1: The EA12 has a wide range of features for AM, SSB and CW reception. Fig. 2: The heart of the EA12 is a diecast coil box carrying the RF stages, flanked by two subchassis and secured to a sturdy front panel. Fig. 3: The date of manufacture can be deduced from the EA12 Serial No. Fig. 4: The ratio arm (arrowed) produces a near-linear frequency tuning scale.


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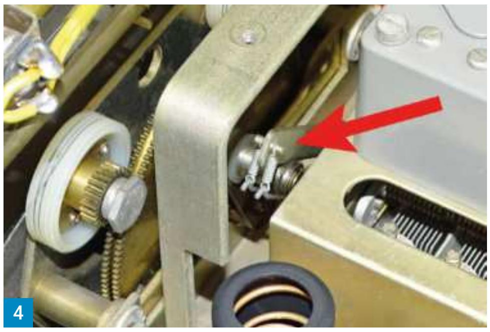
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was a versatile but expensive double-conversion superhet with tuneable first and second local oscillators. The first LO was the main tuning control, giving coverage from 300kHz to 30MHz in nine switched ranges. The second LO was used for incremental tuning over a range of ±100kHz around the first IF of 1350kHz, with conversion to the second IF of 100kHz. The main tuning rate was 250kHz per revolution at 30MHz, while the incremental tuning rate was about 10kHz per revolution, independent of the input frequency.

Edwards realised that if the incremental tuning range of the 830 were increased to 600kHz, then it would be possible to use it to cover the six major (pre-WARC) amateur bands by selecting nine crystal-controlled frequencies for the first LO. (10m being covered in four ranges). The incremental tuning then became the main tuning of the receiver, covering a first IF range of 1.1 to 1.7MHz. In addition to high stability, the low-noise crystal first LO reduces the intermodulation distortion, while the second LO range of 1.0 to 1.6MHz is one over which very high stability is readily achieved.

Thus, the EA12 concept was born, and its 830 foundation was enhanced with several technical refinements of particular value to radio amateurs and SWLs. In spite of the high retail price of up to £185 (over £3000 in today's money) the receiver proved popular and during a five-year period well over 350 sets were sold.

Production

The date of manufacture of an EA12 can be deduced from the Serial No. stamped on a plate affixed to the rear panel next the antenna socket, **Fig. 3**. The first letter of the prefix (A to L) indicates the month from January to December, while the second letter (P to U) indicates the year from 1964 to 1969. For example, Serial No. FS0226 was made in June 1967 and I received it in November of that year. The original Plessey electrolytic HT smoothing capacitors carry their date of manufacture.

Many earlier Eddystone receiver models were identified by an 'S' number, such as S640 and S750. (The 'S' stood for 'specification', not for 'Stratton'). In the factory, the EA12 was designated S923 but the final catalogue prefix EA stands for 'Eddystone Amateur'. The number 12 is arbitrary. The receiver has 13 valves but Harold Cox, who had the final say on Model Nos, thought that 12 was more propitious.

Design

I've provided a high-resolution PDF of the original EA12 circuit diagram for download here:

https://tinyurl.com/y5x5vq8d

and a list of circuit revisions from December 1966 is provided here:

https://tinyurl.com/y46a42ux

The receiver is built around a diecast coil box, which carries the RF amplifier, both LOs and the mixers. This is attached to a sturdy front panel and flanked by two subchassis; with the power supply, BFO/SSB detector and its associated audio filter on one side and the second IF and AF amplifiers, AM detector, AGC rectifier and crystal filter on the other, **Fig. 2**.

The smooth flywheel tuning control drives a spring-loaded split-gear system to eliminate backlash and the cursor travel is about 26cm on each range. To achieve substantially straight-line frequency calibration the mechanism incorporates a linearising ratio arm, **Fig. 4**, the brainchild of Bill Cooke. The reduction ratio of 140:1 results in a tuning rate of about 12kHz per revolution of the tuning knob throughout the range. A quirk is that, as with the S640 receiver, the frequency increases from right to left on the tuning scale. The scale divisions are 10kHz apart and frequencies can be set within 1kHz when standardised with the crystal calibrator. Drift does not exceed 100Hz in any one-hour period and short-term drift is less than 20Hz for temperature changes up to 20°C and 100Hz for a mains voltage variation of 10%.

Calibrator

The crystal calibrator is a self-contained diecast module mounted on top of the first local oscillator cover, **Fig. 5**. It uses a GEC JCF/193 close tolerance 100kHz quartz crystal in an evacuated envelope and a trimmer capacitor allows the frequency to be pulled slightly to align it with an external standard. Since the first LO is crystal controlled, the harmonic output of the calibrator is injected to the second mixer by proximity coupling.

As the fundamental is also fed into the second IF, the BFO doesn't need to be switched on when checking the calibration.

When the calibrator is enabled, the gain of the RF stage is reduced to avoid interference by incoming signals. Having zero-beat the calibrator signal, the cursor can then be moved slightly by a mechanical shift control to align it exactly with the appropriate 100kHz division on the tuning dial. As the calibration signal is introduced at the first IF, it corrects for all the bands at the same time.

On the LF bands, there can be some leakage of the harmonics of the crystal calibrator into the first mixer. As a result of the slight inaccuracy in the frequency of the first LO crystals, this can result in a constant low-pitched beat being heard in the background when tuned to a crystal check frequency. The error is typically of the order of 100Hz, well within the specified accuracy of the receiver.

RF stages

To prevent breakthrough at the first IF, the signal input from the antenna is first passed through a multi-pole highpass filter with an input impedance of 75Ω that attenuates signals below 1.7MHz by at least 90dB. The RF amplifier uses a frame-grid ECC189 double-triode in a cascode (grounded-cathode/grounded-grid) circuit. This has improved signal-to-noise performance on 10m and 15m and provides greater protection against cross modulation and blocking than the 6BA6 pentode amplifier of the S750 and 888A.

The three signal frequency circuits are tuned by a front-panel 'Peak RF' control that is independent of the main tuning. The control has a two-to-one reduction drive and its coverage is restricted to 600kHz except on 10m, where the tuning range is extended to 2MHz to allow coverage of the whole band with a single set of coils.

Oscillator injection from the crystal controlled first LO is on the high side of the signal frequency on all ranges, so that the IF spectrum is a mirror image of the input spectrum. On the lower four frequency ranges injection is at the fundamental crystal frequency, while on the five ranges covering 10m and 15m the triode section of the first mixer acts as a frequency doubler. The HT supply to the crystal oscillator and the amplifier/doubler is stabilised, while that to the tuneable second LO is not. This surprising arrangement was found to reduce the frequency change with variation in mains voltage. The drift produced by a change in the HT voltage is compensated by that caused by the corresponding change in heater voltage! Replace the EC90 oscillator valve V5 in the event of any significant drift or chirp.

100kHz IF Amplifier

The second IF stage of the EA12 has seven tuned circuits in addition to a crystal filter with preset phasing for CW reception. In the S750 and 888 models, Eddystone used a technique pioneered in Hammarlund Super-Pro receivers that allows the selectivity to be varied by a front panel control that alters the coupling between the primary and secondary windings of the second and third IF transformers. In the EA12, this mechanism is applied to three IF transformers instead of two, **Fig. 6**. The selectivity control has detents at bandwidths of 6kHz for AM, 3kHz for SSB and 1.3kHz for CW. Rotating the control further switches in the crystal filter, reducing the bandwidth to 50Hz. IF breakthrough attenuation is greater than 110dB on all ranges and the change of IF centre frequency when the selectivity is varied is negligible.

Another front panel knob controls a slot filter whose narrow 'T' notch can be positioned at any point in the IF passband. With a rejection of over 40dB, the filter is very effective in removing an interfering heterodyne. When receiving SSB signals and not required for interference suppression, it can be used to steepen the carrier side of the passband. Exalted carrier reception of an AM signal is also possible by using the filter to notch out the carrier and taking it as an SSB signal using the BFO. When set 'off', the slot is positioned slightly more than 3kHz from the centre frequency.

A low impedance IF output is provided at a coax socket at the rear of the receiver for use with the Eddystone EP20 panoramic display or ancillary units for decoding digital modes. The sweep width of the EP20 can be reduced to 100Hz for detailed spectral analysis but the maximum display bandwidth is limited by the selectivity of the IF channel to 6kHz.

S-Meter

A feature of the EA12 is the large S-meter fitted on the front panel behind the glass window, **Fig. 7**. 'S1' on the scale corresponds to an input of 2μV at the antenna socket and each division represents a 6dB change in input signal level. This differs from the external Model 669 S-meter used with many earlier Eddystone receivers, which is calibrated at a generous 4dB per S point, allegedly because Harold Cox thought it would make the sets look more sensitive than they really were!

A potentiometer on the rear panel of the EA12 allows the S-meter to be zeroed with a non-inductive 75Ω resistor connected to the antenna socket. Damping resistors are included across the primary windings of some of the tuned circuits coupling the cascode and first mixer stages to maintain the same calibration when changing from band to band. A thermistor can be inserted between the centre tap of the HT winding and ground to prevent the S-meter hitting the end stop at power-on. The meter is controlled by the AGC level and is out of action when the AGC is switched off.

AGC and Noise Limiters

With the AGC on, time constants of 150ms can be selected for AM reception or 4.5s for SSB or CW. When receiving SSB signals there is an automatic reduction in the AGC delay (the signal strength threshold at which AGC feedback begins). The AGC voltage is provided at a rear terminal for recording or control purposes, or for linking receivers for diversity reception if you have more than one of them and don't QSY often!

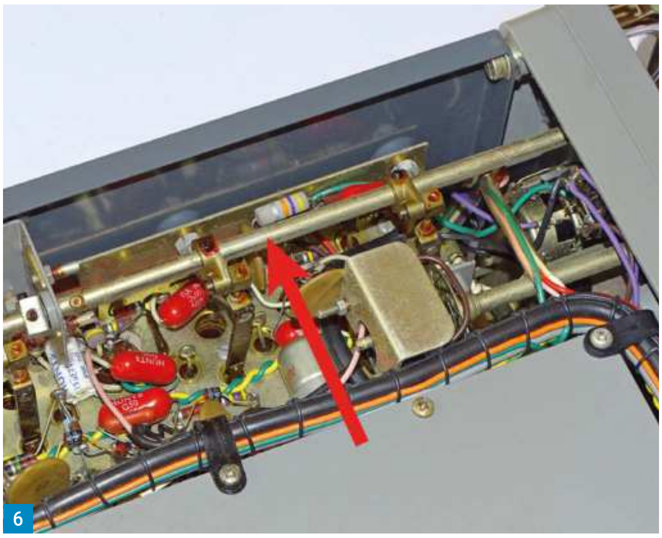
A rear panel control allows the muting level to be set if the standby switch is used for transmit/receive switching, or if the mute input terminal is grounded by an external relay. Alternatively, the receiver can be muted by applying a negative voltage to the AGC terminal. The voltage should be adjusted to suit the strength of the transmitted signal, since the muting level control is not active in this mode. A voltage of -50V is sufficient to mute the receiver completely. A chassis ground terminal next the antenna socket should be used to complete all such external circuits (see Fig. 3 again).

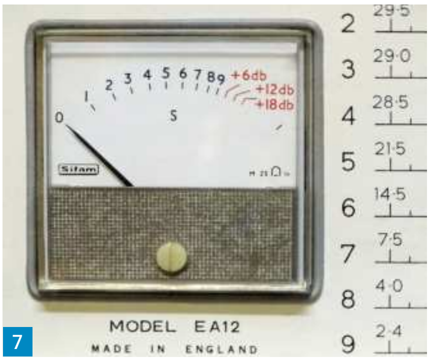
The AGC selector switch also controls the two noise limiters; a simple series diode type for AM and a double-diode clipper for SSB and CW. An internal control for the SSB/CW noise limiter allows the degree of clipping to be adjusted. Advancing the control too far will result in excessive distortion on SSB and a tendency for CW characters to run together because of the square shaping of the keying envelope. This control has no effect on the AM noise limiter.

AF Stages

Separate audio filters are provided for AM and for SSB/CW signals. On AM, the response is within ±3dB (relative to 1kHz) over the range 400-7000Hz. When receiving SSB or CW, the output from the product detector is filtered to modify the audio response to 10dB down at 500Hz and greater than 30dB down at 5kHz. When the CW audio filter is switched in, the circuit is reconfigured to use the same Mullard Vinkor ferrite pot-core inductor as a tuned audio filter with a 6dB bandwidth of 300Hz centred on 800Hz.

In addition to a front panel headphone jack, the EA12 has an internal 11cm diameter loudspeaker at the right side of the cabinet. This speaker is connected to the audio output terminals on the rear panel, which allows it to be





disconnected when an external loudspeaker is used. Unusually for Eddystone, the output transformer is not a potted component. The maximum audio output is 2.5W, with 5% distortion at 1W into 3Ω. A matching Type 906 plinth accessory was available that incorporates an elliptical speaker and tilts the receiver to a convenient operating angle of 13°. Unlike the diecast mounting blocks for earlier Eddystone receivers, the plinth is made of sheet steel. Hence it can easily be customised to accept additional sockets, meters, switches, or other station controls, **Fig. 8**.

Restoration

Today, EA12 receivers in good original (unmolested) condition can be purchased for around £300. If possible, the mains input connector should be procured with the set, since this is quite a rare Bulgin type with asymmetric contact diameters and a side ground clip, **Fig. 9**.

Initially it can be quite difficult to remove the close-fitting cabinet. Place the receiver face down on its handles and remove the four retaining screws. Then apply inwards and upwards glancing blows with the palms of the hands on the long sides of the case. Only if this fails, exert leverage with a screwdriver in the two slots in the leading edge of the underside of the cabinet. Apply Vaseline around the inside edge of the front panel when reassembling.

If the receiver has not been used for many years, old lubricant should be cleaned from the tuning mechanism and the cursor slide to avoid damaging the fine 0.3mm diameter drive wire. When relubricating the moving parts with fresh light oil or grease, apply sparingly and avoid contaminating the stainless steel drive disk that forms part of the main tuning mechanism.

Unlike many earlier Eddystone models, the glass window of the EA12 can be readily extracted for cleaning without the fastidious task of dismounting the front panel. This is achieved by removing the small shaped castings at each end of the dial aperture by accessing their retaining bolts with a 4BA or 6.5mm spanner through rectangular cut-outs in the side panels, **Fig. 10**.

The Achilles' heel of Eddystone receivers of this vintage is not the tuning mechanism, the transformers, the controls, the crystals,

Fig. 5: The beehive trimmers for the tuneable IF are accessible at the side of the crystal calibrator module. Fig. 6: The variable selectivity control acts on all three 100kHz IF transformers. Fig. 7: The large clear S-meter is calibrated at 6dB per S point. Fig. 8: The Type 906 loudspeaker plinth can be readily customised. Fig. 9: The Bulgin EA12 mains connector is polarised by asymmetric contact diameters. Fig. 10: The 4BA bolts securing the glass retaining castings can be accessed through side slots.

Fig. 11: The coil box houses the bandpass RF transformers, the RF coils, the second LO coil and the two Vinkor inductors of the IF bandpass circuit. Fig. 12: EA12 alignment tools: *1* Crystal filter phasing, *2* Beehive trimmers, *3* Vinkor inductors, *4* 2nd LO and 100kHz IFTs, *5* RF bandpass transformers and coils.

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the RF and IF inductors or even the valves, all of which are very reliable. Instead, the most usual cause of inferior performance is the failure of humble fixed resistors and capacitors. Fortunately, these are inexpensive but due to the point-to-point wiring of the receiver it is sometimes necessary to remove several components to gain access to replace a defective one at a deeper layer, particularly inside the coil box, **Fig. 11**. The original soldering is not always to the highest standard, with some component leads just tacked to tags instead of being mechanically wrapped first, but dry joints are rare. The receivers were built entirely by hand and original factory wiring errors are not unheard of.

The least reliable capacitors are the metallised paper ones and the small white electrolytic capacitors, which tend to drift in value or become open circuit. The HT smoothing capacitors rarely give trouble but after more than 50 years it may be wise to replace them in view of the mess that can be produced if they do blow. Adding an inline fuse between the centre tap of the HT winding and the chassis can prevent the diodes or surge resistors acting as fuses in the event of a fault. Wirewound components are stable but carbon composite resistors tend to drift high in value, especially those having a high nominal resistance or carrying a significant DC current. Simple voltage checks and signal tracing will identify most of the defective components and, once these have been dealt with, performance measurements will indicate where further work is required.

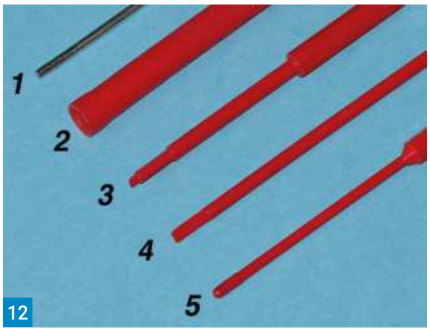
Realignment

Since the tuneable LO has only one range, the realignment of an EA12 is quite straightforward using a signal generator, a DMM and the appropriate trimming tools, **Fig. 12**. In addition to a standard flat-blade non-magnetic screwdriver, these include a hex ferrite core trimmer with a narrow spindle that can be passed through the secondary cores of the RF bandpass transformers to adjust the primary cores below them. A beehive trimming tool is required for the three concentric capacitors, as well as a narrow-bodied screwdriver with a non-magnetic 2mm-wide tip for adjusting the Vinkor inductors used in the first IF bandpass circuit and a 2.1mm diameter tommy bar for the crystal filter phasing.

First, all the second IF transformer cores should be peaked with the 100kHz crystal filter switched in. A wobbulator or equivalent sweep generator is useful for optimising the symmetry of the response curve at wider bandwidths, and for adjusting the phasing control, which is accessible at the side of the crystal filter can. The BFO control has a 5:1 reduction drive and should be adjusted to provide a symmetrical swing of ±3.5kHz on CW and ±100Hz on SSB, centred on the carrier insertion frequency for the sideband selected by the USB/LSB mode switch. When tuning the slot filter notch to the centre of the IF passband, ensure that the control knob is midway between the stops.

Normal tracking procedure applies when realigning the second LO and first tuneable IF stages, with the trimmers being adjusted at the high frequency end and the cores at the low frequency end of the range. But remember that the LO tunes in the opposite direction to the signal frequency calibration on the main tuning scale! The three beehive trimmers are accessible through a slot to the side of the crystal calibrator (see Fig. 5 again), while the LO coil and the two Vinkor inductors of the IF bandpass circuit are located in the two front compartments of the coil box (see Fig. 11 again). The split vanes of the tuning capacitor can be bent to improve the calibration accuracy at the intermediate 100kHz points on the scale.

Alignment of the RF stages should be carried out with the Peak RF control set at 10



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o'clock and the main tuning in the centre of the scale. Using the corresponding signal generator frequencies, the upper and lower cores of the bandpass coils and the cores of the first mixer coils should then be peaked for each band from 160m to 15m in order. Range 2 should be selected for the 10m adjustment. Finally, check that the Peak RF control covers the full range of each band. The CW/SSB filter Vinkor and the antenna input filter should not normally require adjustment.

In spite of its age, a restored and realigned EA12 should fully meet the original performance specification of a signal-to-noise ratio of 10dB at 50mW output with a 2µV input signal 30% modulated at 400Hz, the selectivity control being in the 6kHz AM position. On CW, the sensitivity is 0.5µV for an SNR of 20dB and IF bandwidth of 1.3kHz. With the narrowband crystal filter and 800Hz audio filter switched in and the slot filter optimised, the CW performance of the receiver is outstanding even by modern standards.