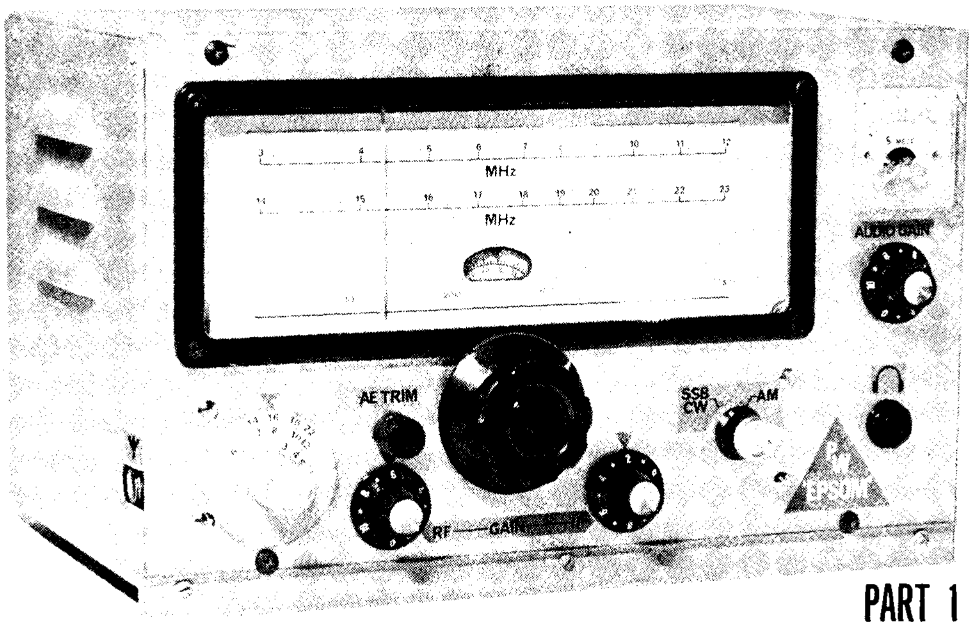


PW EPSOM GENE COVE

PART 1

AFTER listening around the short wave bands on various transistorised receivers it is very evident that they were all prone to an effect known as "cross-modulation". Transistors have a very limited linear input characteristic compared to valves so that early stages in a transistorised set are easily overloaded by strong input signals.

The resulting non-linearity causes strong signals to be impressed upon weak ones even when the two signals are widely spaced in terms of frequency. Two or more strong signals will combine to produce more spurious signals and the general impression is of reduced sensitivity in the presence of strong signals.

The early tuned stages should be capable of rejecting unwanted signals but strong signals can be found to exist on the leads of the transistors themselves by direct pick-up, thus driving them into non-linearity. This effect is not unknown to users of solid state hi-fi equipment when broadcast or TV signals break through from local or semi-local transmitters.

Valves can tolerate input signals of the order of volts before becoming non-linear compared to the few hundred milli-volts of transistors. To the best of my knowledge nobody has yet come up with a practical design for a transistorised receiver front-end that can equal the performance of, say, a valve series-cascode circuit using a common ECC84 and conventional components. To listen round on a receiver so equipped is a revelation, the bands seem to go quiet as the spurious teletype and jamming stations disappear and weak stations can be copied in the presence of strong signals on adjacent channels.

Transmitting radio amateurs are well aware of the problem of cross-modulation, even more so now with the rapid increase in the use of imported transceivers which are generally solid state except for the odd valve or two in the transmitter section. It is interesting to see that one of the latest designs, the FT501, has resorted to a valved front-end using the old fashioned 6BZ6 and 6U8! Nuff sed!

It must be remembered that the mixer stage of a superhet is sometimes the culprit in cross-modulation problems especially if it is preceded by an RF amplifying stage. With an efficient mixer stage an RF stage should not be required. While pentodes and triodes can be used to advantage in front-ends there is another valve, the beam deflection valve, that is even better as a mixer. The 7360 appeared around 1960 but the later and current 6JH8 has better characteristics and is considerably cheaper.

Bill Squires W2PUL repeated (QST September 1963) the principles outlined by Goodman in 1957 that a receiver capable of preventing cross-modulation and overload should have:—

As little gain as possible before applying maximum selectivity.

Excellent linearity in any stage preceding the selectivity.

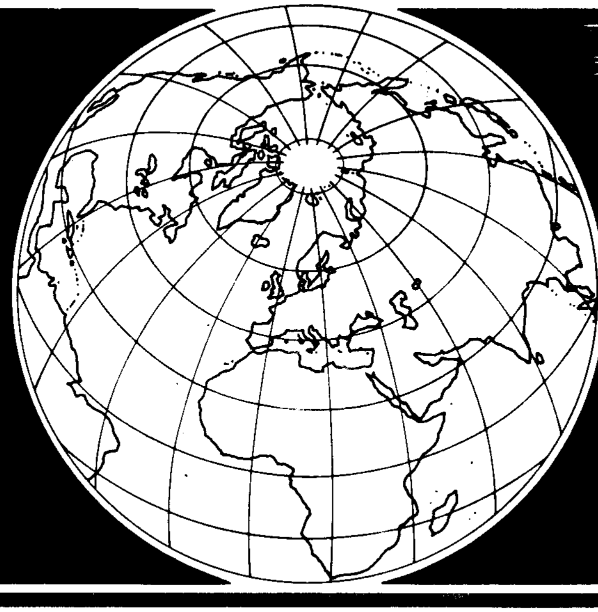
Squires therefore concluded that the ideal receiver should not have an RF stage, as few conversions as possible and that the mixer should be a linear device like a Class A amplifier . . . "conventional mixers perform only because they are non-linear . . . the local oscillator swinging the tube from nearly zero bias to nearly cut-off and no tube is linear near cut-off or near zero bias. As long as the signal is very small compared to the local oscillator voltage the mixer is quite linear but when the signal grows large violent cross-modulation occurs".

He went on to describe a mixer stage using the 7360 in which mixing takes place by switching the valve's electron stream between two anodes by means of deflector plates driven by the local oscillator voltage. See valve symbol V1 in Fig. 2. Up to the deflector plates the valve resembles a conventional pentode.

PW SUPER SEPARATES

ERIC DOWDESWELL
G4AR

:ERAL
RAGE



SHORT WAVE RECEIVER

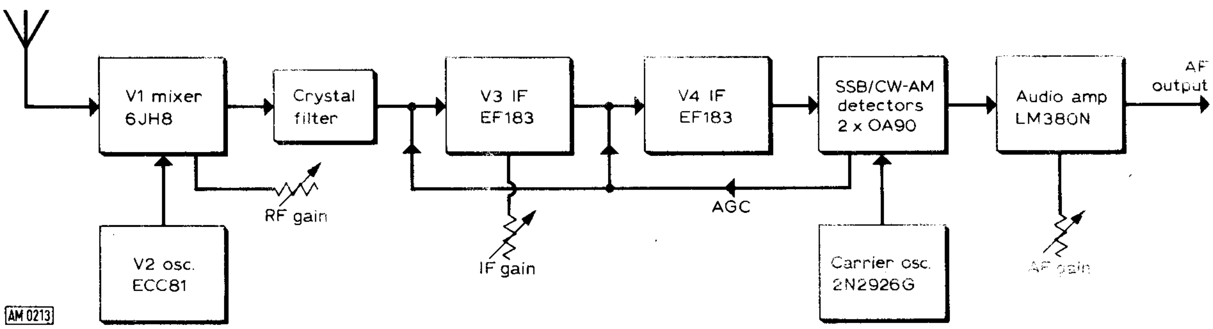


Fig. 1: Block diagram to show the functions of the various stages in the receiver.

W2PUL again . . . "since the two output anodes can be operated in push-pull the valve can be inherently balanced against the input signal frequency, hence good IF rejection".

No RF stage is used with the receiver described here but because of the problem of second channel interference (signals 2 × intermediate frequency from signal frequency) a much higher IF is required than the conventional 455kHz. In this design the IF is 5·5MHz, second channel now being 11MHz away from the signal frequency and adequately attenuated by two tuned circuits at signal frequency. Several circuits and much useful information on the 7360/6JH8 can be found in Pat Hawker's book, **Amateur Radio Techniques** published by the RSGB.

THE DESIGN

The circuit used in the "Epsom" is a hybrid one, using valves in the mixer and two IF stages, where linearity is important, and the first oscillator stage. Diodes are employed in the switchable AM or SSB/CW detector while the associated carrier insertion oscillator (CIO) uses a transistor. The single audio stage utilises an LM380N integrated circuit. The general arrangement is shown in Fig. 1.

In detail, it will be seen from Fig. 2 that the signal passes via the 5·5MHz IF signal trap L1/C1 to the two capacity coupled tuned circuits L2/VC1 and L3/VC2 which feed the signal grid of the 6JH8 mixer V1. Three pairs of plug-in coils cover the whole of the tuning range. The first oscillator V2, an ECC81, employs the very effective cathode coupled oscillator circuit, Fig. 4. Harmonic content is low and a minimum of components contributes to good stability.

The oscillator tuning range is 8 to 18MHz only, no bandswitching being required, the oscillator frequency being added to or subtracted from the input signal frequency in the mixer stage to produce the intermediate frequency of 5·5MHz thus:—

MHz Signal Tuning Range	Osc Tuning Range MHz
2·5 to 12·5	+5·5MHz=8 to 18
13·5 to 23·5	−5·5MHz=8 to 18

The gap between 12·5MHz and 13·5MHz does not contain any broadcast or amateur band. There is also a gap in the tuning around the set's IF of 5·5MHz but again this is not an important part of the short wave spectrum. Another important aspect of this method of mixing is mentioned later when discussing sideband switching.

The oscillator voltage, approx. 5V RMS, is applied to the deflection plates of the mixer. A balanced circuit is desirable here but the practical difficulties

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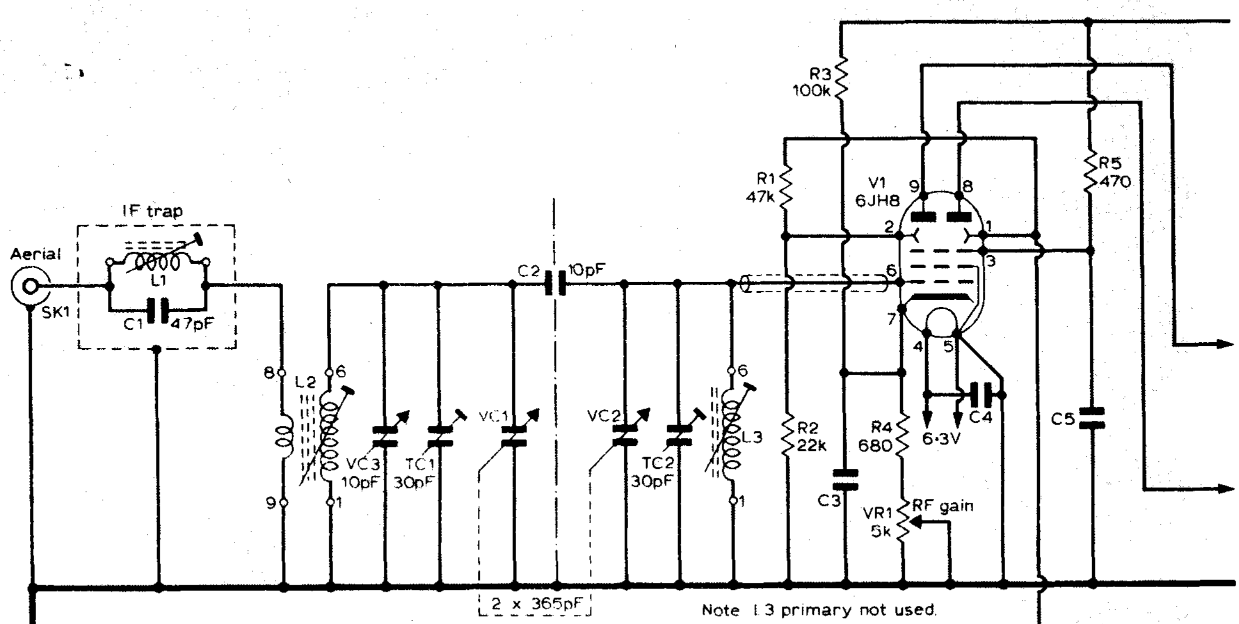


Fig. 2: The input signal is fed to the 6JH8 beam deflection mixer stage via an IF trap and two tuned circuits. The injection voltage applied to the deflection plates is derived from the first oscillator stage, Fig. 4.

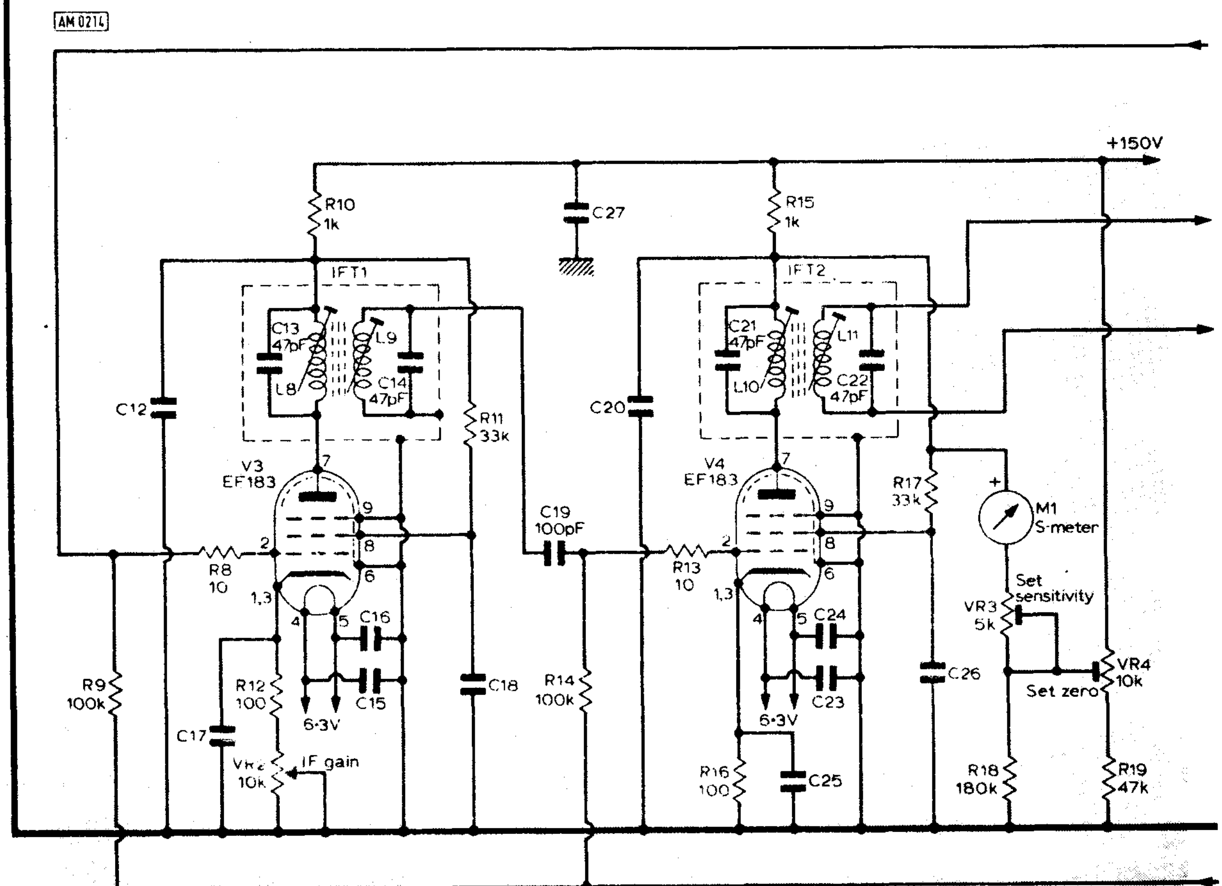
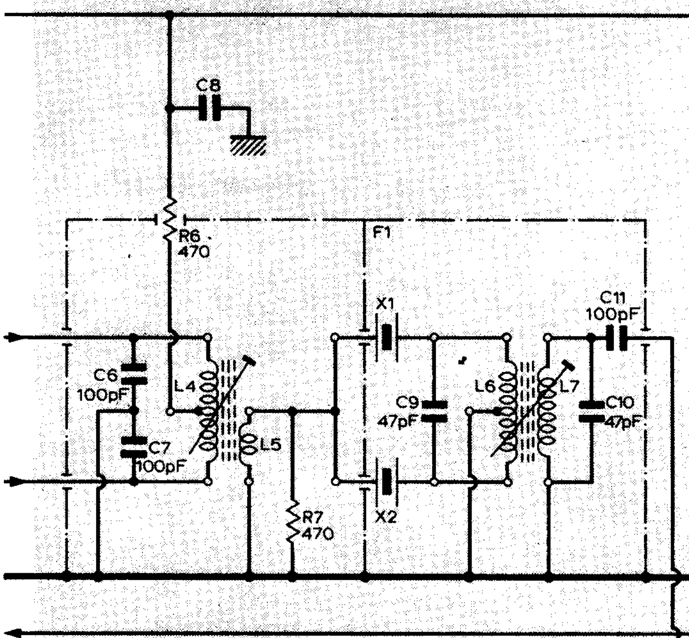


Fig. 3: The low-level signal from the filter is amplified by this two stage amplifier operating at 5·5MHz. Its gain can be controlled manually and by the AGC voltage on AM reception.



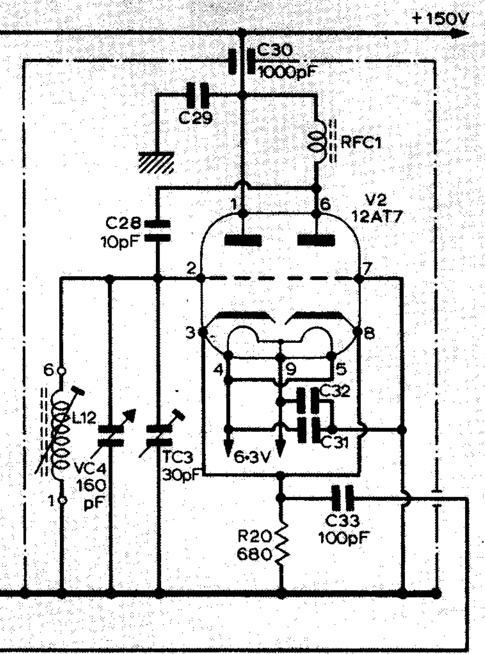


Fig. 2a: The output of the mixer stage, left, feeds into this half lattice crystal filter at 5·5MHz. Input and output circuits must be screened from each other to prevent signal leakage round the filter.

Fig. 4: The first oscillator stage uses very few components. Stability is improved by the absence of any bandswitching complications.

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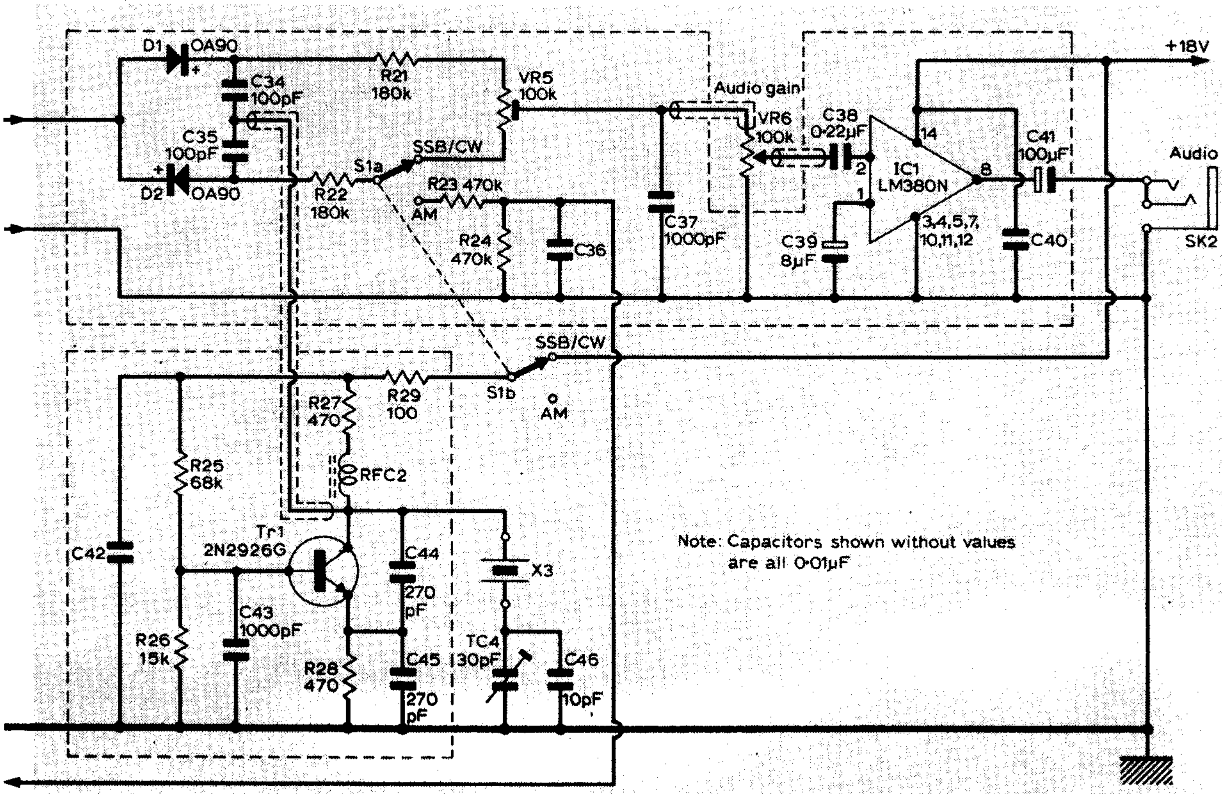


Fig. 5: The output of the IF amplifier, left, feeds a diode detector switchable for optimum operation on SSB/CW or AM reception. The resultant audio is amplified by the LM380N audio IC. The carrier insertion oscillator Tr1 operates only on SSB/CW.

★ components list

Resistors

R1 47kΩ	R11 33kΩ	R21 180kΩ
R2 22kΩ	R12 100Ω	R22 180kΩ
R3 100kΩ	R13 10Ω	R23 470kΩ
R4 680Ω	R14 100kΩ	R24 470kΩ
R5 470Ω	R15 1kΩ	R25 68kΩ
R6 470Ω	R16 100Ω	R26 15kΩ
R7 470Ω	R17 33kΩ	R27 470Ω
R8 10Ω	R18 180kΩ	R28 470Ω
R9 100kΩ	R19 47kΩ	R29 100Ω
R10 1kΩ	R20 680Ω	

All 5% or 10% and $\frac{1}{3}$ or $\frac{1}{2}$ watt

VR1 5kΩ lin.	VR2 10kΩ lin.	VR3 5kΩ lin. preset
VR4 10kΩ lin. preset	VR5 100kΩ lin. preset	VR6 100kΩ log.

Capacitors

C1 47pF SM	C16 0·01μF DC	C31 0·01μF DC
C2 10pF SM	C17 0·01μF DC	C32 0·01μF DC
C3 0·01μF DC	C18 0·01μF DC	C33 100pF SM
C4 0·01μF DC	C19 100pF SM	C34 100pF SM
C5 0·01μF DC	C20 0·01μF DC	C35 100pF SM
C6 100pF SM 5%	C21 47pF SM	C36 0·01μF DC
C7 100pF SM 5%	C22 47pF SM	C37 1000pF DC
C8 0·01μF DC	C23 0·01μF DC	C38 0·22μF DC 25V
C9 47pF SM	C24 0·01μF DC	C39 8μF 25V
C10 47pF SM	C25 0·01μF DC	C40 0·01μF DC
C11 100pF SM	C26 0·01μF DC	C41 100μF 25V
C12 0·01μF DC	C27 0·01μF DC	C42 0·01μF DC
C13 47pF SM	C28 10pF SM	C43 1000pF SM
C14 47pF SM	C29 0·01μF DC	C44 270pF SM
C15 0·01μF DC	C30 1000pF FT	C45 270pF SM
	C46 10pF SM	

DC=Disc Ceramic 250V SM=Silver Mica FT=Feedthrough

VC1/2 2 x 365pF (Jackson 02) VC3 10pF variable

VC4 160pF variable (Jackson Wavemaster 92/057/160)

TC1/2/3/4 30pF airspaced trimmers, beehive type

Semiconductors

D1/2 OA90 IC1 LM380N Tr1 2N2926G

Valves

V1 6JH8*	V2 ECC81 (12AT7)
V3 EF183	V4 EF183

* obtainable from Electronic Component Supplies, Thames Avenue, Windsor, Berks.

Crystals

X1 5·5008MHz X2 5·5024MHz X3 5·5000MHz

Nominal frequencies. A kit of the three crystals (Type HC6U) with holders is available from Senator Crystals, 36 Valleyfield Road, London SW16 2HR for £7·43 inc. VAT and P/P. Kit reference SC/PW/533

Inductors

L1 see text

L2/3 'Blue' Ranges 3, 4 and 5, two of each. (Denco miniature dual purpose)

L4/11 see text

L12 'Blue' Range 4 (Denco miniature dual purpose)

RFC1/2 RF choke 2·5mH miniature, ferrite core

Metalwork

Aluminium cabinet and panel (12 x 7 x 7in.) (Type W)

Chassis 9 x 6$\frac{3}{4}$ x 2in. but see text

Aluminium box with lid 3 x 2 x 1in. (1 off) 4 x 2$\frac{1}{4}$ x 1$\frac{1}{4}$in. (1 off)

Screens from 18swg aluminium 15 x 1$\frac{3}{4}$in. with $\frac{1}{4}$in. flange.

Panel bracket 4 x 4in.

The above metalwork is available from H. L. Smith & Co. 287 Edgware Road, London W2.

Miscellaneous

Valveholders B9A (ceramic or PTFE) with skirt and screen (4 off) without skirt (2 off). Switch S1 2 pole 2 way wafer switch. 14 pin DIL socket for IC1. Dial, Eddystone Type 898 or Jackson Type 4103 see text. Slow motion drive (Jackson Type 4511/4). Flexible coupling for $\frac{1}{4}$in. spindle.* Coil formers 1$\frac{3}{4}$in. x $\frac{1}{4}$in. dia. with square base (Home Radio CR12) and screening cans (CR13) (5 off each). Dust cores (CR19) (7 off). Sk1 coaxial aerial socket. Sk2 stereo jack socket. S-meter 1mA Type MR52P (Henry's Radio). Calibrated knobs (3 off) (H. L. Smith Type F21). Plain knobs (3 off). Screened cable, 4 way. Stand-off insulators (12 off).*

Veroboard 5 x 1$\frac{1}{4}$in. 0·1in. matrix, 2$\frac{1}{2}$ x 1$\frac{1}{4}$in. 0·15in. matrix. Veroboard plain 2$\frac{1}{4}$ x 1$\frac{1}{2}$in. 0·15in. matrix.

*Available from H. L. Smith & Co.

involved are not easy to overcome. The output circuit of the mixer is kept very carefully balanced however so that any input signal voltages present at the mixer output are cancelled out as far as is possible, as mentioned previously. A small trimming capacitor is sometimes added to one side or the other of the mixer anodes circuit to ensure best balance but it was not thought to be necessary here.

The IF filter unit Fig. 2a is full screened to prevent signal leakage across the filter and comprises two crystals X1 and X2 in a half lattice arrangement, with associated coils. Senator Crystals have agreed to supply a kit of these crystals plus the carrier insertion oscillator crystal X3 and three holders. The crystals are produced to close tolerances and it is hoped thereby that readers will be able to reproduce the results obtained by the author without too much difficulty. Commercial HF crystal filters are very expensive but perform better, of course, than the simple filter used here.

A feature of this particular receiver is that with a CIO crystal of precisely 5·5MHz and a single tuning range in the first oscillator the calibration problems are very considerably reduced, as will be seen later during the alignment procedure.

The filter output from L7 goes to conventional IF amplifying stages V3 and V4, Fig. 3, using EF183 frame grid valves. "Conventional" is perhaps not quite correct since the IF stages are operating at 5·5MHz! The signal grids are also connected to the AGC line and the gain of V3 can also be varied by the IF gain control VR2. The S-meter monitors signal levels on AM and is operated by V4, the AGC voltage being derived from the signal. IFT1 and IFT2 peak the 5·5MHz IF signal which is then fed from L11 to diodes D1 and D2, Fig. 5, which are switched

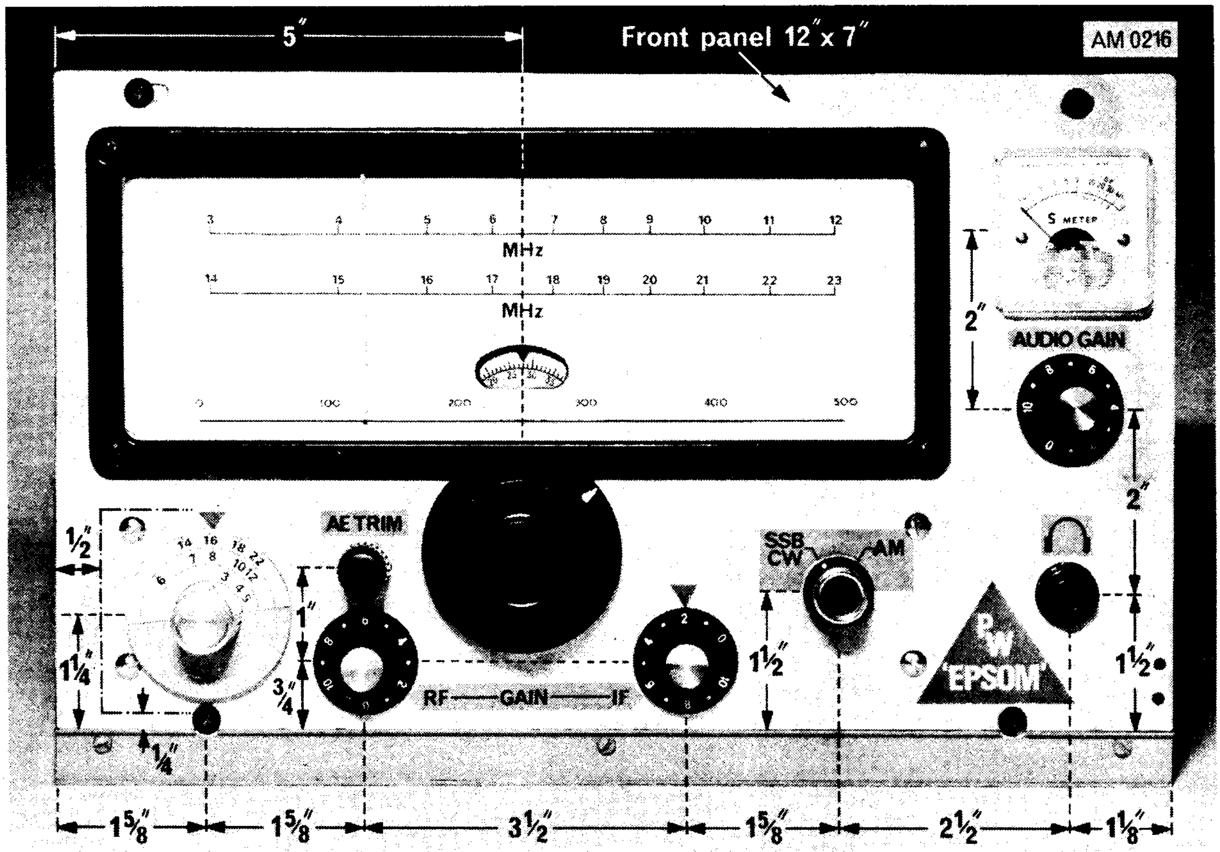
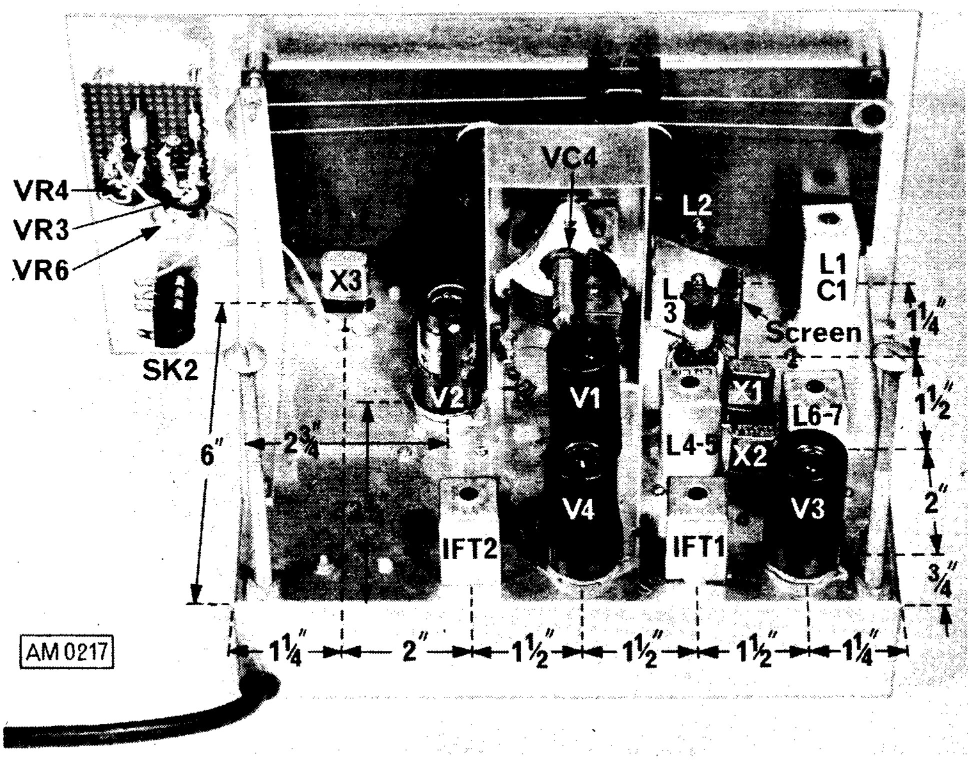


Fig. 6: above. Location of the components mounted on the panel is shown in this photograph. The left hand edge of the chassis is indicated to show its position on the panel. Fig. 7: below, identifies the components mounted on top of the chassis. The long bolts, subsequently removed, are of great assistance when working on wiring etc. inside the chassis.



by S1 to operate either as a normal diode detector on AM or as a product detector on SSB and CW. In the latter modes the crystal controlled CIO, Tr1, is switched on and fed to the diodes via C34 and C35.

The CIO crystal X3 is 800Hz lower in frequency than X1 in the filter unit and it is important to note that the change from lower sideband (LSB) to upper sideband (USB) is automatically achieved by the additive and subtractive method of mixing mentioned previously. Thus only one CIO crystal is required. Generally LSB is employed below 10MHz and USB above. The precise frequency of X3 is adjusted by TC4 for best resolution of SSB signals.

The negative AGC voltage is obtained from the detector stage on AM only, being developed across R23 and R24 and fed to the IF stages V3 and V4. An SSB/CW the product detector output is switched across the preset resistor VR5 which can be adjusted to give virtually complete rejection of an AM signal, the null being quite sharp. This adjustment ensures correct operation of the PD on SSB/CW.

From VR5 the audio signal goes to the volume control VR6 before feeding the audio IC. Capacitor C39 on pin 1 of the IC helps to reduce hum and noise on the 18V supply line. (Further information on using the LM380N IC can be obtained from the December 1973 issue of *PW*). The output of the IC is fed via C41 to the panel stereo headphone socket Sk2. The output impedance is low, intended to operate a speaker of 4-16 ohms, but in this case a pair of stereo headphones is used, the units being connected in parallel at the socket. This may be a breakaway from the conventional high impedance headphones generally used with receivers but it is hoped that since stereo headphones are now very commonplace it will induce short wave listeners to use them instead of a loudspeaker!

Another point to note is that the AGC voltage is not applied to the mixer stage since it is very unlikely that it will ever be overloaded! In consequence the usual signal grid DC blocking capacitor and resistor are omitted which means that large blocking voltages cannot build up on the signal grid, such as can occur in the vicinity of a transmitter.

The number of components has been kept to a minimum, only 29 resistors in the receiver proper and 46 capacitors of which 21 are 0·01μF decoupling capacitors! With the exception of components comprising the various tuned circuits (RF and IF) the values of the resistors and capacitors generally are not very critical, an important point in a period of component shortages. Resistor R20 in the cathode circuit of the first oscillator V2 was adjusted carefully for maximum oscillator output to the mixer stage and the value of 680 ohms specified should be used. An attempt has also been made to reduce the number of different values required of resistors and capacitors.

CONSTRUCTION

Remember that the valves, S-meter and crystals are relatively fragile so do not undertake the drilling or cutting of any holes in the chassis when any of them are in position on the chassis, especially if a power drill is being used. In practice it is unnecessary to touch them at all until after all the wiring is completed and double checked.

When wiring the valveholders fit any old unserviceable B9A based valves into the valveholders. This

★ components list

POWER SUPPLY UNIT

R1	33Ω ½W	C1	350μF 350V
R2	5kΩ 10W WW	C2	2000μF 30V
R3	100Ω ½W	C3	2000μF 30V
R4	22kΩ 2W	F1	Fuse 1A
R5	33Ω ½W	F2	Fuse 250mA

Miscellaneous

D1/2/3, 1N4007. S1, 2 pole on-off. S2, Single pole on-off. Fuseholders (2). Valveholders B7G (2). Cable plug B7G. Panel indicator lamp 6·3V. T1, Transformer 250-0-250V 80mA, 6·3V + 6·3V (Douglas MT1AT). Case 8 x 6 x 6 in. (H. L. Smith & Co. Type U). RV1, voltage stabiliser OA2. Speaker 6 x 4 in. elliptical 8Ω, with cable and jack plug. Speaker grill.

For convenience the components list for the power supply unit is given here. The unit will be described in Part 2.

will keep the pin sockets in their correct positions and prevent any soldering resin from entering them. Once the wiring to the holders has been completed don't forget to remove the old valves! If construction periods are limited it might be some while before the work is finished and the old valves could be easily overlooked. A short-circuited heater winding could result, or even worse!

The chassis as supplied by H. L. Smith to go with their cabinet and panel is 11 x $6\frac{3}{4}$ x 2in which is 2in longer than that used in the prototype. If this chassis is used it is only necessary to keep the various stages in the positions round the edges, as shown in the layout, increasing the length of the leads from the output of the IF strip, L11, to the product detector board. More space will be available in the centre of the chassis and a possible refinement could be the placing of the CIO board and its external components in a separate screened compartment.

The general layout of the components on the chassis and panel is shown in the photographs Figs. 6 and 7, but it is not necessary to copy it precisely provided the usual precautions are taken with screening between stages, short wiring in RF circuits etc. The dial used in the prototype, an Eddystone E898, has seen service on several other bits of equipment over the years and a new one today is rather expensive. The Jackson 4103 dial, available from H. L. Smith Ltd., is a suitable substitute having blank calibration scales as well as a two-speed drive mechanism.

Once the major cut-outs and holes have been made in them the panel and chassis can be bolted together, after ensuring that all burrs on holes have been removed. Then, two 5in bolts, about $\frac{1}{4}$in dia, are bolted temporarily to the rear of the chassis top. These are absolutely invaluable in keeping the chassis level when it is upside down for wiring and testing and they need only be removed when the set is finally installed in its cabinet.

The fitting of the main internal screens can be left to the end when all the wiring is finished, small cut-outs being made along the inside edges of the screens as required to clear wiring passing under the screens.

Part 2 will continue with the construction of the 'Epsom' and also deal with the power supply. The simplified alignment procedure will then be described.