A Wobbulator Unit

by Raymond Haigh

Alignment of radio receivers can be optimised by means of this simple and inexpensive unit which enables the IF response to be displayed on an oscilloscope screen

A glance through any edition of *Radio Bygones* will reveal the skill and effort readers expend on the restoration of vintage radio receivers. And having lavished so much care on the case, components and chassis, many would no doubt wish to take a closer look at the performance of the set.

Experienced restorers will be able to align an IF strip with a fair degree of accuracy by ear (see *Restoration of a Typical Superhet* elsewhere in this issue). However, the standard servicing procedure, in which a high impedance voltmeter is connected across the AGC line to indicate peak response, speeds up the alignment process and makes it more precise. Although perfectly adequate, this tells us nothing about the receiver's selectivity or its IF passband characteristics.

A servicing aid known as a wobbulator permits the keen enthusiast to give the procedure the same meticulous attention he or she has lavished on the receiver's appearance. It represents the ultimate refinement of the alignment process, enabling the response curve of the IF strip to be displayed on an oscilloscope screen so that performance can be optimised with extreme accuracy.

Bandwidth at various attenuation factors can be checked, thus permitting a compromise to be effected between sensitivity, selectivity and audio frequency response. Moreover, the performance of more complex receivers can be made to accord more closely with the manufacturer's original specifications. Even when perfect alignment is not an absolute priority, the unit will enable the downright curious to take a good look at how the vintage receiver is processing the signal.

Principle of Operation

A wobbulator is no more than a signal generator, the frequency of which is repeatedly swept over the IF passband of the receiver under test. Frequency variation is controlled by the timebase or horizontal output of the oscilloscope with which the unit is used. In this way the sweep is synchronised, and the oscilloscope displays the response curve of the receiver's IF stages.

Block diagram Fig. 1 shows how the wobbulator, oscilloscope and receiver are connected together. It should be noted

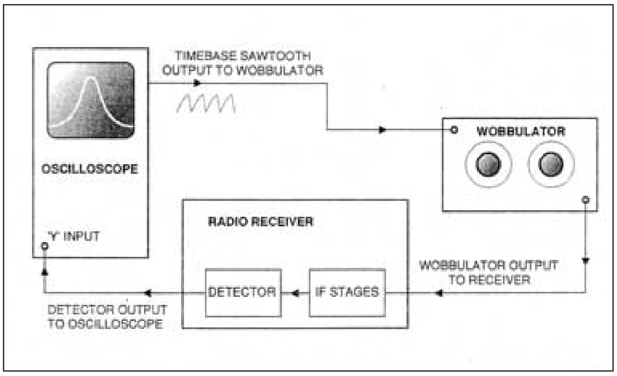


Fig. 1. Connections between the wobbulator, oscilloscope and receiver.

that the RF signal is rectified by the detector before being connected to the 'Y' input, and a high performance oscilloscope with an extended frequency response is not required. So long as the timebase sawtooth waveform is available externally, almost any basic oscilloscope will suffice.

Varying the Wobbulator Frequency

Early instruments of this kind used a motor driven tuning capacitor to shift the frequency of the oscillator. During the valve era, reactance valve circuits were developed, and this enabled the frequency to be varied electronically. Subsequent advances in semiconductor technology produced the varactor or varicap diode, which exploits the way the capacitance of a semiconductor junction can be changed (and hence the frequency of the tuned circuit in which is it used) by varying a reverse bias voltage.

Frequency can also be shifted by varying the supply voltage to the valve or transistor in the oscillator circuit. This method carries the risk of introducing amplitude modulation (which would distort the oscilloscope display), and it can be difficult to secure sufficient swing. It is, however, effective as a means of varying the frequency of a multivibrator, and oscillators of this kind, which are tuned by RC (resistor/capacitor) rather than LC (inductor/capacitor) circuits, have formed the basis of some wobbulator designs intended for the alignment of 450kHz to 470kHz IF stages.

Unfortunately, the operation of multivibrators becomes less predictable as frequency is increased, and it was decided that using a varicap diode to shift the frequency of a conventional Hartley oscillator would ensure more repeatable results in a unit designed for operation up to 15MHz.

The Circuit

The circuit of the wobbulator is given in Fig. 2. Field effect transistor, Q1, is the active device in the Hartley oscillator circuit tuned by inductors L1 to L4, and varicap diode, D1. Gate and source of Q1 are connected to the appropriate coil by range switch SW1.

Blocking capacitor, C3, prevents the reverse bias that controls the varicap diode being grounded via the tuning inductor, and R9 ensures the correct working conditions for Q1. Diode, D2, limits the amplitude of oscillation and prevents forward conduction of the JFET's gate. It also keeps oscillator output across the four switched ranges reasonably constant. The stage is decoupled from the supply rail by R10 and C6.

Signal output is taken from the source of Q1 and connected to the gate of Q2 via coupling capacitor, C7. This source-follower (or common drain) buffer stage minimises loading on the oscillator and isolates it from the equipment under test

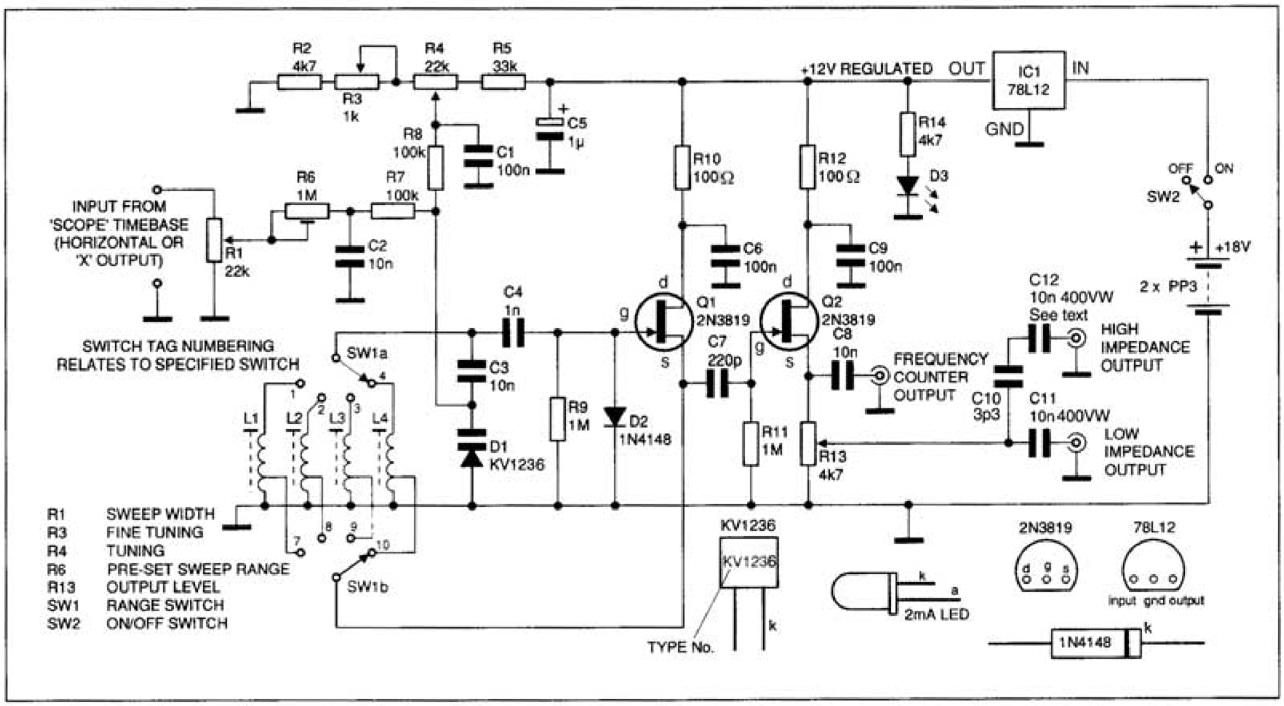


Fig. 2. Circuit diagram of the wobbulator

in order to prevent any frequency pulling or other disturbance to its operation. Correct biasing of the buffer stage is ensured by R11, and R12 and C9 decouple it from the supply line.

Output is developed across source load, R13, a potentiometer that sets an appropriate signal level for the equipment under test. The low value DC blocking capacitor, C10, enables the signal to be injected into a high impedance circuit without excessively disturbing its operation. The output via the higher value blocking capacitor, C11, should be chosen when the injection point presents a low impedance or when the connecting lead must be screened.

With valve radios, signal injection points can be held at fairly high DC potentials. The working voltage of C11 and C12 should, therefore, be at least 350V DC. Low value (3.3pF) silver mica capacitors with this working voltage are still manufactured, but are no longer widely retailed. Therefore the High Impedance Output is connected via C12, a 10nF 400V polyester capacitor; this series capacitor will provide the necessary protection.

Readers with access to a frequency counter may wish to use it with the wobbulator. It should be connected directly to the source of Q2 via blocking capacitor, C8. (The wobbulator output potentiometer is usually turned well down, and the voltage on the slider is not then sufficient to trigger most counters).

Current drawn by the unit is approximately 10mA and operation by batteries is, therefore, perfectly feasible. Bias for the tuning diode is derived from the power supply rails, and precautions must be taken to ensure that tuning doesn't drift with falling battery voltage. Accordingly, two PP3 batteries are connected in series to give a nominal 18V, and this is held at 12V by means of the 100mA regulator, IC1. Tantalum capacitor, C5, is included to bypass any electrical noise generated by the regulator IC.

Equipment of this kind can be inadvertently left switched on. Low current LED, D3, and dropping resistor, R14, are included to minimise the chance of this happening.

Oscillator Tuning

Wobbulators often incorporate a conventional air-spaced variable capacitor to set the oscillator to the IF centre frequency. A varicap diode, wired in parallel with it and coupled to the oscilloscope timebase, produces the necessary frequency sweep.

This wobbulator is tuned, and its frequency shifted, by a single varicap diode of the type developed for medium-wave receivers. These devices provide a capacitance swing of around 450pF with a tuning voltage range of 2V to 9V, and exhibit a 'Q' factor of at least 200. Although they are more expensive than a varicap with a smaller swing, the need for a conventional tuning capacitor is avoided and the overall saving in cost is significant. More important, wide frequency sweeps are easy to obtain, and the full IF passband, together with a portion of the RF spectrum on either side, can be displayed.

The capacitance/tuning voltage relationship of the chosen diode is reasonably linear up to about 6V. Between 6V and 9V the rate of capacitance change falls. Below about 1V, the 'Q' factor of the diode reduces.

Tuning bias for the diode is taken from the slider of potentiometer, R4, and fixed resistors, R5 and R2, limit the voltage swing from around 1V to 5.5V. Potentiometer, R3, acts as a fine tuning control, and capacitor, C1, eliminates potentiometer wiper noise.

Timebase Input

Potentiometer, R1, determines the amplitude of the sweep input voltage, and pre-set resistor, R6, enables the range of this control to be adjusted to suit most modern oscilloscopes.

The timebase sawtooth voltage can be checked by turning down the time/cm controls until the spot drifts slowly across the screen. The pointer of a DC voltmeter, connected between oscilloscope timebase output and ground, should then move slowly enough for the minimum and maximum sweep voltages to be read off. The oscilloscope used with the prototype wobbulator generated a sawtooth waveform running from around 15V to 25V. If much higher voltages than this are encountered, wire a resistance in series with R1 in order to reduce the input to the required level.

Again, C2 eliminates potentiometer wiper noise, and R7 and R8 isolate the varicap diode, at signal frequencies, from the tuning voltage networks. (The diode passes virtually no current, so the isolating resistors have no effect on the tuning voltage).

Components

Most n-channel JFETs should be suitable in this circuit, but base connections vary and should be checked.

Toko coils, varicap diodes, the specified FETs and 350V working silver mica capacitors, can be obtained from JAB Electronic Components, PO Box 5774, Birmingham, B44 8PJ. Tel: 0121 682 7045 (**http://www.jabdog.com**). At the present time this firm can only accept mail orders. Toko coils can also be obtained from Coils-UK, Ltd, 12, Elder Way, Langley Business Park, Slough, Berkshire, SL3 6EP, Telephone 01753 549502.

The varicap diodes are supplied in snap-apart packs of two (KV1236) or three (KV1235) for ganged receiver tuning.

An inexpensive, two-pole, six-way plastic-cased Lorlin rotary switch can be used for S1. This item, together with the remaining parts, is available from a number of suppliers, including JAB. Coils-UK specialise in Toko coils and are unable to supply other parts.

Construction

All of the components, with the exception of the switches, potentiometers, capacitor C12, and the LED indicator, are mounted on a small PCB. The component side of the board is illustrated in Fig.3 and the full-size copper track layout is given in Fig.4. solder pins, inserted at the lead-out points, will simplify the task of wiring up the off-board components.

It is convenient, with equipment of this kind, to have the input and output sockets mounted on the front panel. This does necessitate a slightly larger case, but the unit can still be accommodated in a standard plastic box with external dimensions of 198mm × 112mm × 64mm (Maplin catalogue No. H2852).

A photocopy of Fig.5 can be used for the front panel, and the finished panel protected from soiling by a sheet of thin Perspex (the type of material used for DIY double glazing). For reasons which will become clear later, it is neither feasible nor necessary to calibrate the tuning dial.

Switches, potentiometers, terminals and circuit board are all mounted on the lid of the box and the assembly is

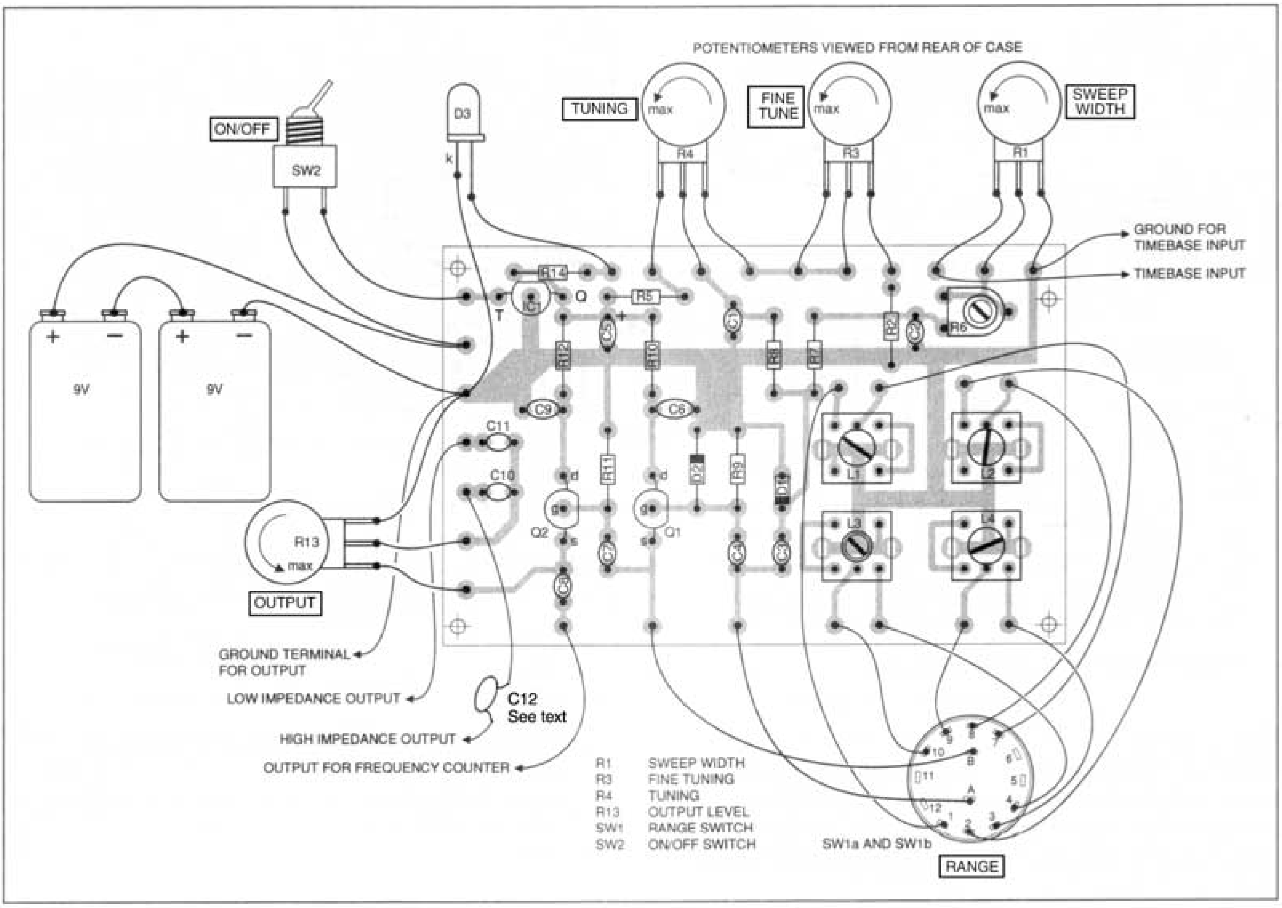


Fig. 3. Printed circuit board layout and wiring to all off-board components

depicted in the photographs. The battery holder is formed from scrap aluminium sheet and held in place by the on/off switch bush and one of the terminals.

Remember to check the orientation of semiconductors and the tantalum capacitor, and to check the PCB for poor soldered joints and bridged tracks, before mounting it in position.

Setting Up and Testing

Connect up the batteries and switch on. Current consumption should be in the region of 10mA and the voltage at the output of IC1 should be precisely 12V.

Set R1 and R3 to mid travel and use a radio receiver or frequency counter to check that the oscillator is working on all four ranges and can be tuned by R4. With *no* input from the oscilloscope timebase, coverage of the prototype unit is as follows:

Range 1	350 - 600kHz
Range 2	1 - 2MHz
Range 3	3 - 6MHz
Range 4	6 - 14MHz

The above tuning ranges can be varied, within reasonably wide limits, by adjusting the inductor cores. Note that with L1, L2 and L3, inductance increases, and frequency lowers, as the cores are driven down. The core of L4 has to be set flush with the top of the can for maximum inductance.

Connecting the timebase input increases the reverse bias on the varicap diode and, for a given setting of the tuning control, this increases the frequency of oscillation. In

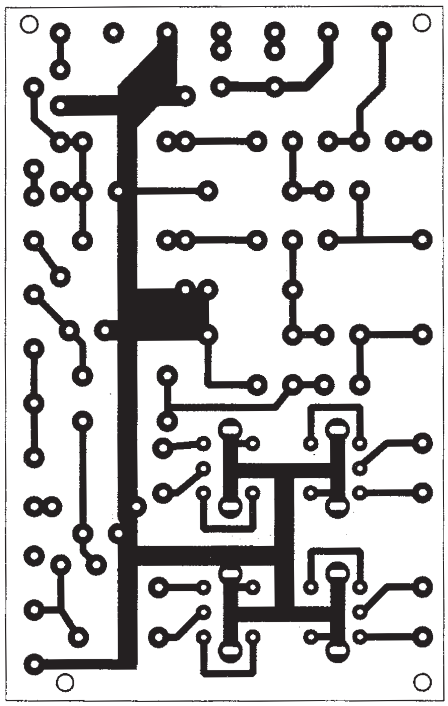
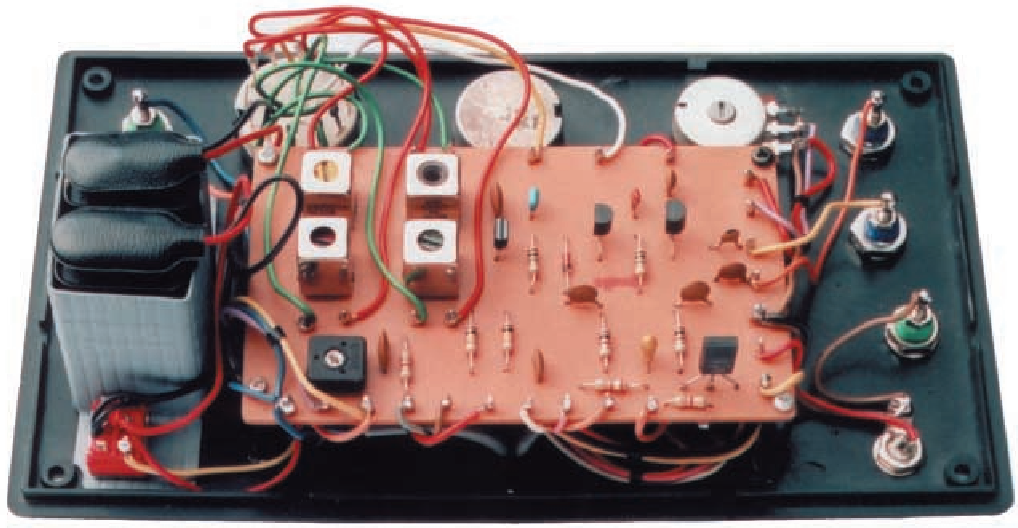


Fig. 4. Full size master foil pattern for the printed circuit board



Interior assembly and PCB of the wobbulator

practice, the unit should be capable of producing displays of IF systems centred at up to 15 or 16MHz.

Using the Wobbulator

Connections between the wobbulator, oscilloscope and receiver under test are shown in Fig. 1. Keep the wobbulator close to the receiver so that the signal injection lead can be as short as possible. The connection between the receiver's detector and the 'Y' input of the oscilloscope may have to be screened, but this was not found to be necessary with the equipment used for the initial trials.

A transistor portable radio can be used for the test and the signal should be injected into the base of the mixer/oscillator transistor. Connect the 'Y' input of the oscilloscope to the audio side of the diode detector. Link the ground terminal on the oscilloscope to the ground terminal on the wobbulator and the ground plane on the receiver.

The oscilloscope timebase should be set for the lowest possible sweep rate consistent with an acceptable amount of flicker in the trace. (The display will be distorted, especially when narrow band filters are being checked, if too fast a sweep setting is chosen). The 'X' gain control should be turned well down.

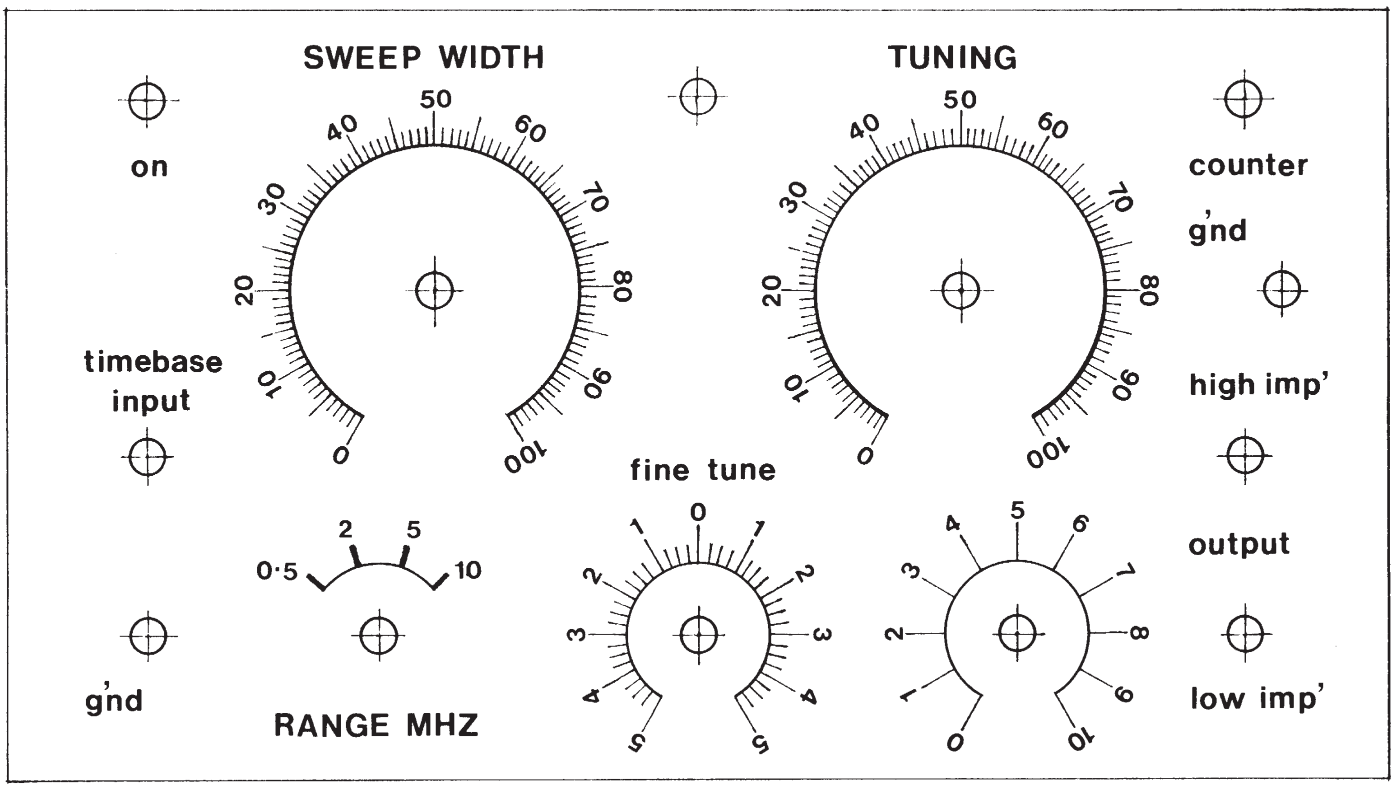


Fig. 5. Front panel of the Wobbulator Unit shown actual size

Wobbulator Components List

Resistors

R1, R4	22k linear potentiometer (2 off)
R2, R14	4k7 (2 off)
R3	1k linear potentiometer
R5	33k
R6	1M pre-set potentiometer, horizontal type
R7, R8	100k (2 off)
R9, R11	1M (2 off)
R10, R12	100Ω (2 off)
R13	4k7 linear potentiometer

All fixed types ±5% tolerance, 1/4 Watt rating

Capacitors

C1, C6, C9	100nF (3 off)
C2, C3, C8	10nF (3 off)
C4	1nF
C5	1μF tantalum
C7	220pF
C10	3p3
C11, C12	10nF 400V DC working polyester (2 off)

All ceramic types, 25V working or greater unless otherwise stated

Inductors

L1	RWO6A7752EK (green core)
L2	154FN8A6438EK (violet/deep red core)
L3	154FN8A6439EK (yellow core)
L4	KXNK3767EK (pink core)

All by Toko – see text

Semiconductors

D1	KV1236 or KV1235 (varicap diode, see text)
D2	1N4148 signal diode
D3	2mA LED
Q1	2N3819 JFET
Q2	2N3819 JFET
IC1	78L12 (12V regulator, rated 100mA)

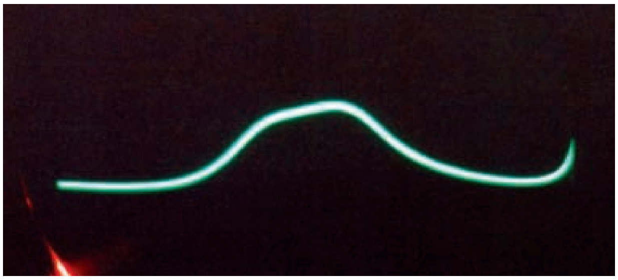
See text for details of suppliers of Toko coils and varicap diodes.

Switches

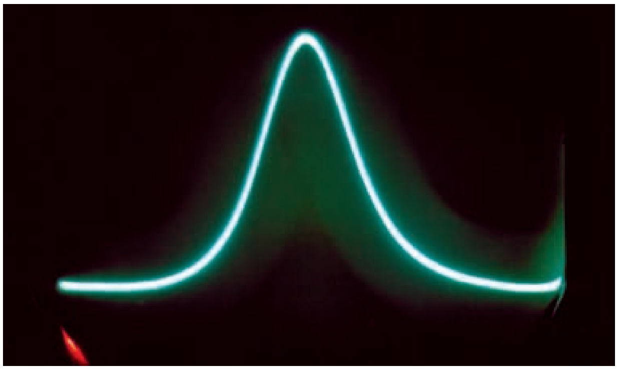
SW1	2-pole 6-way, Lorlin plastic cased rotary switch
SW2	single-pole, single-throw toggle switch

Miscellaneous

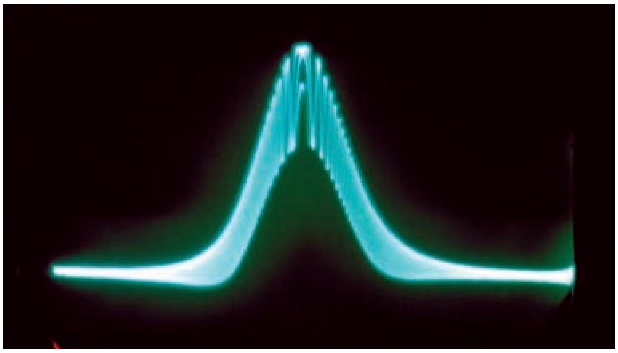
Printed circuit board (No. RB1 – available from the *RB Editorial Office*, price £5.95). Solder pins and hook-up wire. Stand offs for mounting PCB and self-tapping screws. Control knobs, terminals (5 off), phono socket for counter, LED holder, battery connectors. Plastic box or other enclosure, materials for front panel and scrap aluminium for battery holder.



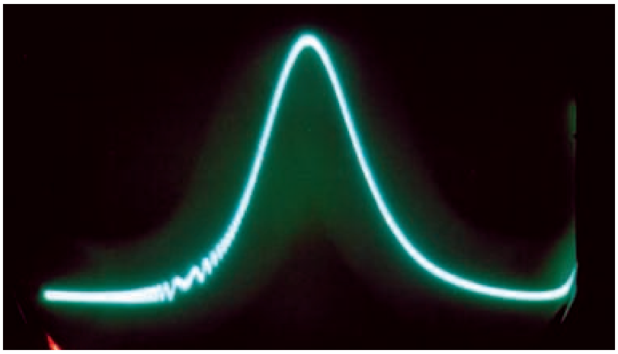
Oscilloscope trace of IF response of a transistor portable radio, before alignment



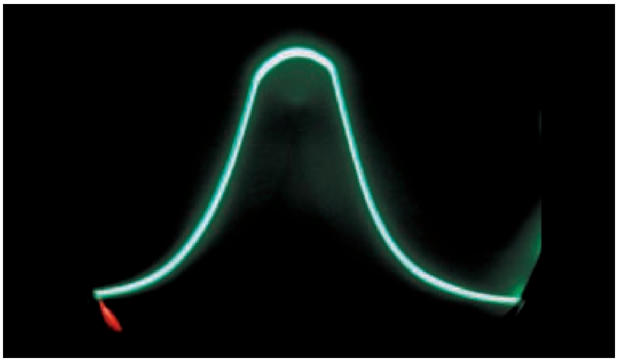
Oscilloscope trace of the same radio, after alignment



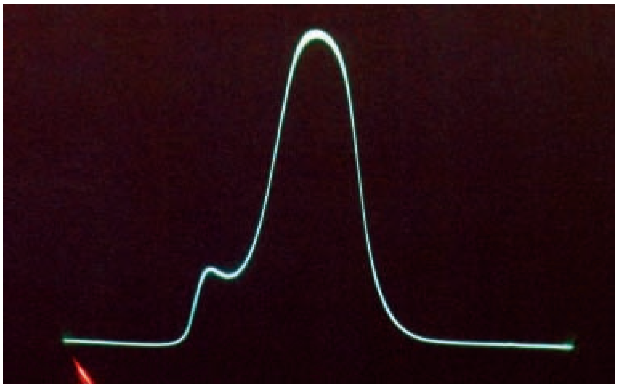
Using a second signal generator to pinpoint frequency along the trace. Zero beat point at crest of peak and second generator dial reading 460kHz



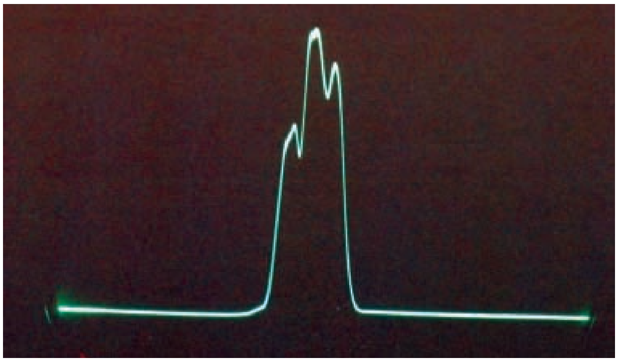
As the previous photo, but zero beat point set close to floor of trace and second generator dial reading 470kHz



Flattening of trace caused by too high an injection level resulting in receiver overload



Trace produced by an IF strip comprising four tuned transformers and an inexpensive 4kHz mechanical filter. Receiver aligned for maximum sensitivity



Trace produced by an IF strip comprising four tuned transformers and a 2.6kHz ceramic filter. Again, receiver aligned for maximum sensitivity

Switch the wobbulator to the appropriate range (invariably Range 1, or 0.5MHz, for a transistor portable AM radio), set the sweep width control to about half travel and adjust the wobbulator tuning until the receiver's IF response is displayed on the oscilloscope screen. Turn down the signal level (R13) in order to check that the receiver's IF stages are not being driven into clipping: this results in a flattening of the displayed peak, as illustrated in the top photograph above.

The timebase sawtooth voltage does not drop to zero with respect to ground, and increasing the timebase input will drive the wobbulator frequency higher as well as shifting it more, and the tuning control has to be turned back to compensate for this. Adjustments to the oscilloscope's 'Y' input sensitivity, the 'X' gain control, wobbulator output and sweep width all affect the profile of the display. Turning *up* the sweep width control will *reduce* the width of the passband profile because it is occupying a smaller proportion of the frequency range displayed on the screen.

This all sounds rather complicated but, in practice, the unit is very easy to set up and operate.

Valve Superhets

Superhets of the valve era, other than some very early and primitive designs that did not have AGC circuitry, develop a voltage across their detector diode load resistor that is negative with respect to chassis. Similarly, most transistor receivers in current production have the detector diode wired to give a negative going output. This will generate a trough rather than a peak on the screen, but the trace is still perfectly useable. Early solid-state receivers, with germanium *pnp* transistors (OC44, OC45, OC170, OC171 etc), normally have the detector diode connected to give a positive-going output with respect to chassis. This results in a peaked trace.

Adjustment of the IF transformer trimmers or cores will, of course, change the profile of the display. If the restored radio is to be used for domestic listening, modern band conditions suggest that they be adjusted for the highest and sharpest peak. Turning up the 'Y' sensitivity and adjusting the other oscilloscope controls until the tip of the peak almost fills the screen enables the cores to be set with extreme accuracy.

This is, however, a matter of personal preference, and restorers who like to stagger tune the IFTs to produce a flatter passband and a better audio response will be able to see the results of their efforts displayed on the screen.

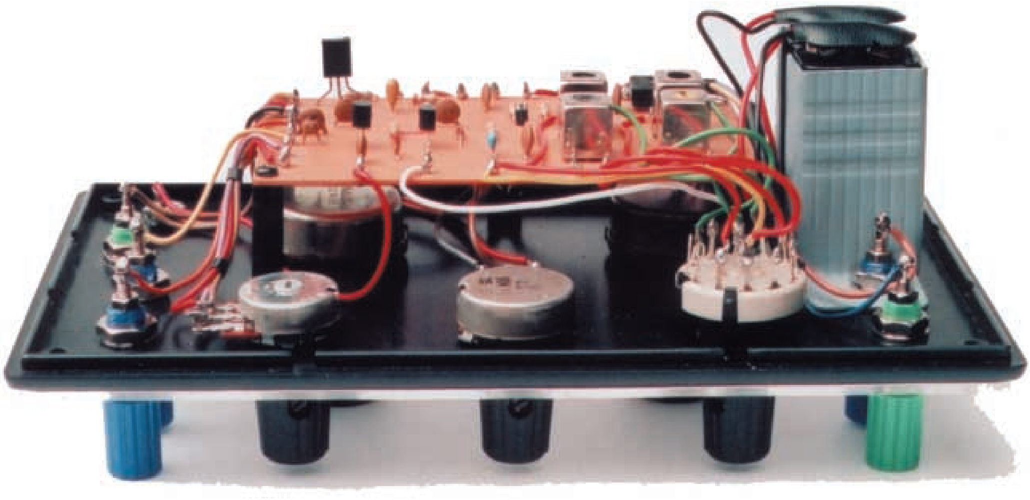
Some authorities recommend that the receiver's oscillator stage and AGC network be disabled in order to avoid any distortion of the trace. However, if the injected signal is kept as low as possible, and if the aerial is disconnected from the receiver (tune portables to a silent part of the dial), no problems should be encountered with spurious responses.

The effectiveness of the simple output attenuation control, R13, diminishes as frequency increases, especially when the high impedance feed is used, and it may be necessary to place the signal lead close to the injection point, rather than make a direct connection, in order to keep amplitude sufficiently low.

Some of the traces likely to be encountered are shown in the various photographs.

Measuring the Bandwidth

Vintage receivers, with their large, high 'Q', double-tuned IF transformers will often out-perform modern transistor receivers. Some readers may wish to determine the frequency at the crest of the peak and at various attenuation points down the skirt of the IF response curve. To do this, place the output lead from another signal generator close to the output terminal of the wobbulator. The second generator must be tuned to the receiver's IF, its output turned well down, and modulation switched off. The trace on the oscilloscope will become fuzzy and broader. If the frequency of the second generator is now swept slowly across the IF passband, a gap or notch will move along the broader trace. This represents



the zero-beat position, where the frequency of the second generator precisely coincides with the frequency displayed on the trace. The notch will be shallow at the bottom of the skirts, where receiver sensitivity is low, and deep at the crest of the peak, where receiver sensitivity is at its greatest. The photographs of actual traces should make this clear.

Multiple Conversion Receivers

Additional equipment is needed to investigate the response of front-end tuned circuits and IF filters in multiple conversion receivers, as they do not feed directly into the detector. Moreover, signal levels can be too low to produce a display on the oscilloscope. A suitable RF probe unit, which amplifies and detects the signal, will be described in the next issue of *Radio Bygones*.

Some high performance receivers, designed towards the end of the valve era, have complex, multi-section LC filters after the first frequency changer. Special equipment, produced by the receiver manufacturer, is often needed for the proper alignment of radios of this kind. Enthusiasts are urged to ensure that they have the necessary data and test gear before disturbing the adjustment of these complex and valuable receivers. ***RB***